GEORGE C. GORDON LIBRARY

WORCESTER POLYTECHNIC INSTITUTE
WORCESTER, MASSACHUSETTS 01609

WORCESTER POLYTECHNIC INST LIBRARY

Inside Chemical Engineering • London Project Center

WPI Journal

ORCESTER POLYTECHNIC INSTITUTE SUMMER 1987

Staff of The WPI JOURNAL: Editor, Kenneth L. McDonnell • Alumni Information Editor, Ruth S. Trask
Alumni Publications Committee: Samuel Mencow '37 , chairman • Paul J. Cleary '71 • William J. Firla, Jr. '60 • Carl A. Keyser '39 • Robert C. Labonté '54 • Maureen Sexton Horgan '83.

The WPI Journal (ISSN 0148-6128) is published quarterly for the WPI Alumni Association by Worcester Polytechnic Institute in cooperation with the Alumni Magazine Consortium, with editorial offices at the Johns Hopkins University, Baltimore, MD 21218. Pages I–XVI are published for the Alumni Magazine Consortium [Franklin and Marshall College, Hartwick College, Johns Hopkins University, Villanova University, Western Maryland College, Western Reserve College (Case Western Reserve University), Worcester Polytechnic Institute] and appear in the respective alumni magazines of those institutions. Second class postage paid at Worcester, MA, and additional mailing offices. Pages 1–14, 31–44 © 1987, Worcester Polytechnic Institute. Pages I-XVI © 1987, Johns Hopkins University.

Staff of the Alumni Magazine Consortium: Editor, Donna Shoemaker • Wrap Designer and Production Coordinator, Amy Doudiken Wells • Assistant Editor, Julia Ridgely • Core Designers, Allen Carroll and Amy Doudiken Wells.

Advisory Board of the Alumni Magazine Consortium: Franklin and Marshall College, Linda Whipple and Patti Lawson • • Johns Hopkins University, B.J. Norris and Elise Hancock • Villanova University, Eugene J. Ruane and D.M. Howe • Western Maryland College, Joyce Muller and Sherri Kimmel Diegel • Western Reserve College, David C. Twining • Worcester Polytechnic Institute, Michael Dorsey and Kenneth L. McDonnell.

Acknowledgments: Typesetting, BG Composition, Inc.; Printing, American Press, Inc.

Diverse views on subjects of public interest are presented in the magazine. These views do not necessarily reflect the opinions of the editors or official policies of WPI. Address correspondence to the Editor, The WPI Journal, Worcester Polytechnic Institute, Worcester, MA 01609. Telephone (617) 793-5609. Postmaster: If undeliverable please send form 3579 to the address above. Do not return publication.

CONTENTS

WPI JOURNAL
Volume XCI No. 1
Summer 1987

2 **The President's Message** *Dr. Jon C. Strauss*

Independent Technological Universities: Aiming at the 21st Century

4 **In the Labs of Goddard Hall** *Leslie Brunetta*

WPI's excellence in chemical engineering continues—in traditional and emerging fields.

12 **The Entrepreneurial Spirit: Room with a View** *Michael Shanley*

Fred Molinari '63 climbed to the top of the computer industry.

I **An Album on Aging**

II **A Mirror on the Middle Years** *John T. Bethell*

They're not so bad after all.

III **Seven Answers to the Question, What's the Best Age to Be?** *Julia Ridgely Photos by Peter Howard*

VI **Lifestyle, Illness, and Longevity** *Peggy Eastman*

Sorting the normal from the abnormal in growing old. Plus a look at elixirs, a warning about tanning, and thoughts on facing death.

31 **London Bridges Building Up** *Kenneth McDonnell*

WPI's London Project Center got underway with an evening of ritual—and plenty of hard work.

38 **Info-Tech: Better Access to Expanding Knowledge** *Evelyn Herwitz*

Gordon Library celebrates 20 years in the midst of an information-technology revolution.

Letters Inside back cover

Page 4

Page 12

Page XII

Page 31

Page 38

Cover: June skies behind Boynton Hall. Photo by Jon Reis. Opposite: Prof. Robert E. Wagner joined the Chemical Engineering Department in 1949. Nearly four decades later, the Department carries on its pioneering spirit. Photo by Michael Carroll.

THE PRESIDENT'S MESSAGE

Independent Technological Universities: Aiming at the 21st Century

By Jon C. Strauss

Beginning 120 years ago with its original colonial colleges, American higher education has evolved to the land grant universities, the independent "polytechnic" schools (of which WPI was the third to be chartered), the liberal arts colleges, the comprehensive universities, and now to the modern research universities. Given the needs of contemporary and future society, the breadth of mission of these various types of institutions, and the changing character of contemporary "polytechnic" schools, a question needs to be addressed: What is the best course for WPI—a polytechnic now being transformed into a technological university—as it approaches its 125th year and prepares for a new century of progress?

Charting a course for the next decade is a particularly timely issue as American higher education is being subject to intense criticism. William Bennett, secretary of education, recently stated that colleges and universities are in danger of losing public support because of their failings in undergraduate education. A great deal of scrutiny has also focused on the proper role for technical subjects in engineering, business, and science in a four-year college education. R.J. Franke, president of a major investment banking firm, joins a common refrain in saying: "Humanities educate us to live, and vocational training teaches us to earn."

Moreover, the recent Carnegie Foundation Report on Higher Education cites a conflict between "careerism and the liberal arts," stating that "narrow vocationalism, with its emphasis on skills training, dominates campuses.

As if these indictments of higher education weren't enough, Allan Bloom, in his book *The Closing of the American Mind*, states that students who use the university as training grounds for professions merely go through the college experience with "blinders on, studying what the chosen discipline imposes." Bloom further alleges that such a student

is generally motivated not by love of his field of interest, but by love of money from the career that will follow. Similar concerns have been voiced by many in business, in higher education, and in government.

How should institutes of technology respond to these concerns? The value of the applied sciences in the undergraduate curriculum is under attack. Interestingly, this situation is not new; its history is both revealing and humorous. The applied sciences have long struggled against accusations of being vocational and secondary. As long ago as ancient Greece, for example, Xenophon spoke for many of his fellow citizens in Athens when he proclaimed that "the mechanical arts carry a social stigma and are rightly dishonored in our city." Technologists, he maintained, "simply have not the time to perform the offices of friendship or citizenship. Consequently they are . . . bad friends and bad patriots."

In the 1630s, the Marquis of Worcester proposed that England's great universities present instruction in the various national industries. The Marquis argued that men with talent in invention and industry were men of great genius and should be considered scholars. Himself an amateur inventor and scholar, the Marquis fought to promote this "new education." But he had come upon his idea at the wrong time: With Oliver Cromwell on one side and Archbishop Laud on the other, and England's civil war brewing in between, the Marquis' thoughts fell on deaf ears. He died bankrupt, and for two centuries more, England's universities refrained from instruction in anything but the classics.

The industrial revolution provided the catalyst that ultimately changed curricula. After centuries of intellectual prejudice hampering studies in the applied sciences by the world's scholarly community, the needs of growing industrial nations finally created an undeniable demand for their acceptance. But this societal need did not always enhance these areas of inquiry to equal status among the more classical disciplines.

For instance, Yale and Harvard universities took bold steps in the late 19th century by creating "scientific schools" that incorporated studies bearing on modern industries. But these scientific schools had a severe drawback. Their new studies were not presented on a par with more classical studies. Both institutions kept their scientific schools separate, even physically isolating them from the rest of campus, and giving their graduates certificates instead of diplomas.

Eventually, two types of colleges evolved with specific instruction in the mechanical and industrial arts. The land grant universities had, and continue to have, strong ties to agriculture, animal husbandry, and mechanical arts—the skills necessary to support the economy of a rapidly expanding nation. The same economic needs that motivated the land grant universities prompted the development of the polytechnic schools. WPI—founded in 1865—and its predecessors—RPI in 1834 and MIT in 1864—were established to satisfy the technological

needs of their communities of origin. In the case of WPI, those needs focused on preparing young men from the immediate locale to staff the burgeoning industries and factories of Worcester. WPI was successful in this enterprise, as were over a dozen other similar institutions.

Harold Shapiro, Princeton University's new president, has noted that the primary concern of early American colleges was the preservation and the promotion of morality. Little emphasis was placed on the development of new ideas. But as the world changed dramatically in the 19th and 20th centuries, so did the mission of its academic institutions. Just as the industrial revolution created a need for technical education in engineering, science, and business, World War II served as a similar agent of change for altering higher education's technical emphasis. This conflict established that basic scientific research was essential for a nation to maintain its military and economic strengths.

The modern research university is the direct result of this interpretation, and has become the major factor in American higher education in the relatively brief 40-year period since. These institutions grew out of some of the land grant universities, comprehensive universities, and polytechnics. They are characterized not only by the scope and breadth of their faculty scholarship, but also by the intensity and success of their faculties at obtaining external sponsorship for their research, largely from various federal agencies. CalTech, MIT, and Carnegie-Mellon University (formerly Carnegie Tech) are good examples of polytechnic colleges that have transformed themselves into research universities.

These four decades that saw the emergence and growth of the modern research university also saw tremendous changes in the polytechnics. Some, like CalTech and MIT, did more of the same, but better, while others, like Carnegie Tech and Case Tech, achieved recognized research university status by affiliation with other institutions. But key to the change in all of the former polytechnic institutions (including WPI and the other members of the Association of Independent Technological Universities) in the last half of this century is a new emphasis on scientific research.

WPI is a good example of this change in the breadth of the polytechnics. Following founder John Boynton's emphasis on academic instruction and mindful of founder Ichabod Washburn's concern for practical, shops-oriented education, WPI continues to emphasize both theory and practice. This is the "Two Towers" tradition captured in the WPI motto *Lehr und Kunst* (learning and skilled arts) and is embodied in the original two towers (Boynton for academics and Washburn for shops). Today, this approach to higher education is also embodied in the WPI Plan—outcome-oriented education that blends theoretical studies and practical application through project work.

WPI must devote significant resources toward faculty development.

While the scope of both the origins and employers of WPI students has broadened considerably in the past 120 years, WPI remains closely tied to this nation's industries. Yet now, through active programs of research, WPI is also initiating new developments, processes, and directions for industry as well as responding directly to its needs for trained engineers, scientists, and managers. In this, WPI remains true to its founders' directive to create or discover and to convey knowledge at the frontiers of academic inquiry for the betterment of society, while responding to the very different world today.

The evolution of engineering in higher education and the recent recognition of the polytechnics as technological universities help bring focus to my question above regarding the best course for WPI in preparation for the 21st century.

The recent report on "Engineering Education and Practice in the United States" predicts an evolving future. It foresees likely characteristics of the engineering environment in the year 2000 to include longer time horizons for profit-taking, shortages of capital and resources (both energy and materials), a global economy with increased intra- and interindustry competition, increased government demand for engineering goods and services, continued high rate of scientific discovery and technological development, and an increased requirement for nonadvanced engineering tasks.

Reports such as this and the Carnegie Report must be considered when determining a future course. Fortunately, WPI is healthier than many peer technological universities with respect to the reports' recommendations. For example, the Carnegie Report raises one question above all others: "Can the liberal and useful arts be blended during college, as they must inevitably be blended during life?" To accomplish this and other objectives, the Carnegie investigators propose several criteria:

- The student's field of study should include a written thesis that relates some aspect of the major to historical, social, or ethical concerns.
- Every student should write a senior thesis, and present this report in an oral defense to colleagues and fellow students.
- Students should be measured by the outcome of their education, not by curriculum requirements fulfilled.
- While not all professors need be publishing researchers, they nonetheless should be first-rate scholars.

These specifications are well met by the "outcome"-oriented WPI Plan, which has been evolving at WPI over the

Continued on inside back cover

WPI's excellence in chemical engineering continues—in traditional and emerging fields.

In the Labs of Goddard Hall

By Leslie Brunetta

"THE EXTRAORDINARY THING about WPI's chemical engineering department," says Associate Professor Robert Thompson, "is that we rank among the top universities in at least three areas of research—zeolites, biochemical engineering, and catalysis. Considering how small the department and the college are, that's pretty remarkable."

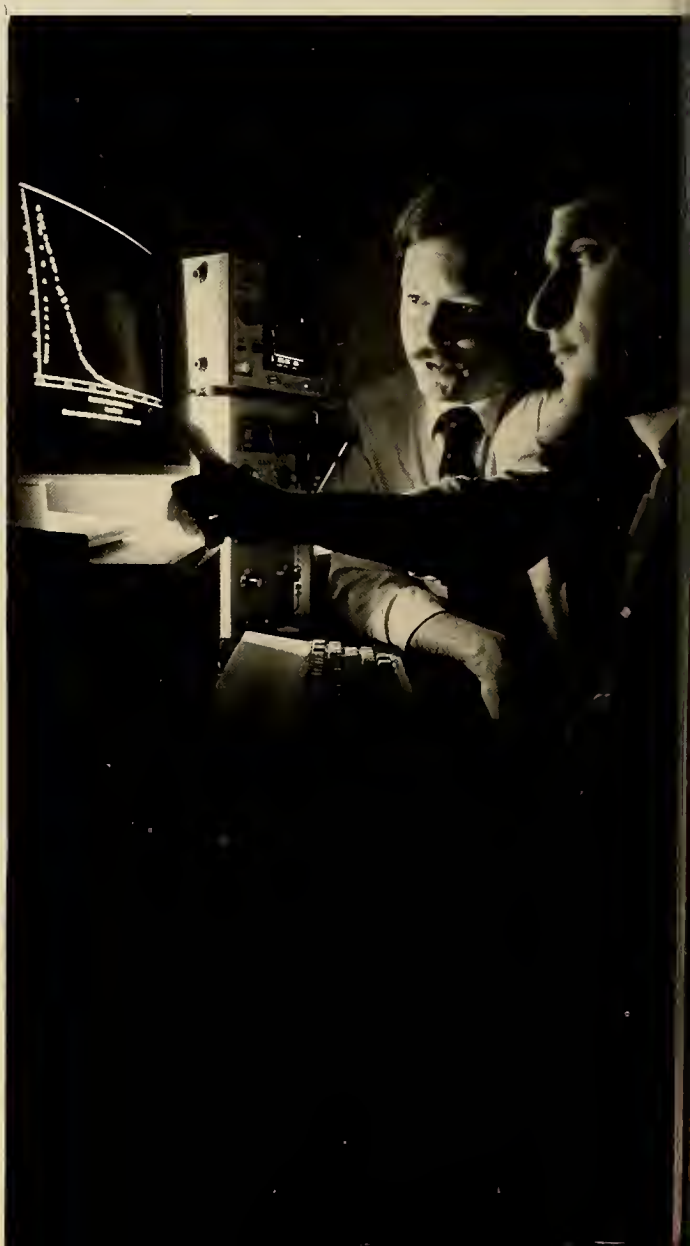
While the MITs, CalTechs, and Purdues of this country can boast chemical engineering faculties of 30 or more, WPI's department supports a staff of just 10 active faculty members. But, as David proved to Goliath, strength doesn't always depend on size: sometimes commitment, clear aim, and focused energy can put you on top.

FOR MORE than a decade, WPI has been an internationally known center for zeolite research. When the inferno of molten magma at the center of the earth breaks its bounds, igneous rock is formed as lava belches up to the earth's surface and meets cooling air or water. In the cavities of these rocks can be found about 40 varieties of zeolites—minerals consisting of hydrous silicates. Like all other minerals, zeolites are crystals, and so their atoms are arranged in regularly repeating patterns.

Fortunately for chemical engineers, and for the rest of us who rely on a variety of chemical products in our daily lives, these patterns have been found to be extremely useful tools in a number of chemical processes, particularly in the production of liquid fuels and new chemicals. So useful, in fact, that over the years chemical engineers have gone to the trouble to synthesize an additional 150 or so zeolites.

"I was recently at a conference in Tokyo," says Thompson, "and someone came up to me and said, 'Oh, you're from the WPI zeolite group. You're the only ones in the country who are doing any reasonable work.' We get comments like that frequently, and it's a good feeling."

Thompson's acquaintance may have been exaggerating WPI's standing a bit, but the fact that WPI has a larger zeolite research program than any other academic institution



in the country and that the department can be counted on to be a star participant in virtually every major zeolite conference is taken for granted by the rest of the chemical engineering world community.

WPI owes this fame in part to the pioneering work of Professor Leonard Sand, who died in September 1985. Sand joined the department in 1967 after spending eight years as head of a Norton Company research unit developing synthetic zeolites. During his nearly 20 years at WPI, Sand's enthusiasm for the promises zeolites held out for industry and research rubbed off on the department's other members, with the result that now nearly half of them are involved in some aspect of zeolite research.

Because of the properties of their crystalline structures, many zeolites act as molecular sieves—they allow some molecules to pass through them but not others. This chemical gate-keeping activity is essential to the zeolites' role in catalysis, a process central to the workings of the whole chemical industry.

A catalyst, such as a zeolite, either kicks off or affects the rate of a chemical reaction without itself being chemically changed by the reaction. That's important: The reaction might take place in nature anyway, but so slowly as to be of little use.

Two ways in which zeolites act as catalysts are department research specialties: adsorption—in which a thin layer of the reacting molecules sticks to the zeolite surface—and diffusion—in which gas or liquid molecules pass through a zeolite.

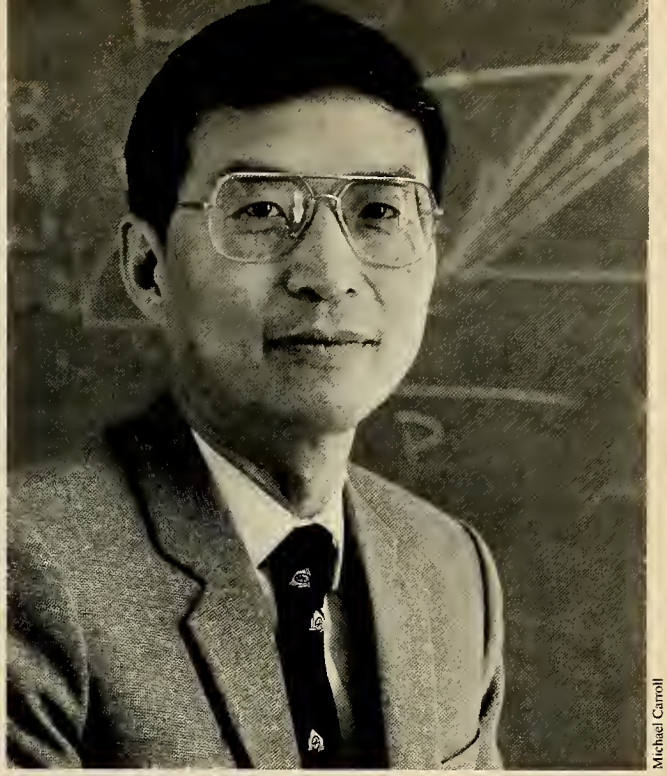
Department Head Professor Yi Hua "Ed" Ma's primary research interests are in the adsorption and transport properties of reactants as they diffuse through porous materials, including molecular sieve zeolites. This research is of fundamental importance to catalysis because how—and how quickly—a reactant travels through and around a catalytic site on its way to the reaction site determines how efficient a reaction will be. Ma studies both intercrystalline diffusion (how a reactant gets from one crystal to another) and intracrystalline diffusion (how a reactant gets through a single crystal) with the goal of helping industry better predict the most efficient sizes for reactors and flow patterns for reactants.

Ma is also trying to help scientists and industry by reconciling seemingly contradictory results that have appeared in research literature. Over the years, many people have tried to measure zeolites' adsorptive and diffusive properties by using nuclear magnetic resonance techniques and gravimetric analysis.

But the two techniques often produce extremely different measurements. Ma hopes that, through a more rigorous approach, he'll be able to resolve these different measurements and come to an understanding of the two properties that will make catalytic use of zeolites more predictable.

Ma's work in this area is an NSF-sponsored, cooperative effort with WPI colleague Associate Professor Anthony Dixon and Clark University Professors Alan Jones and Paul Inglefield.

A new area of Ma's research is inorganic membranes—materials (including aluminas and zeolites) that may find applications in many industrial processes. Almost without his expecting it, Ma's work in zeolites has propelled him to leadership in the field. In fact, Alcoa has given him $100,000 to establish the country's only academic center for inorganic membrane research.



Michael Carroll

Opposite: Associate Professor Robert W. Thompson (l.) works with M.S. student Richard Correia on a partial size analyzer for measuring zeolite crystal size distribution. Above: Professor Yi Hua "Ed" Ma heads a department that has long been one of the Institute's most distinguished.

These membranes would be made up of inorganic materials (oxides) through which a fluid would pass. As the fluid passed through it, the fluid's diffusion properties would cause some of the fluid's components to separate out. The successful use of inorganic membranes could provide industry with an extremely efficient way to cull valuable products.

In 1986 Ma was elected to a six-year term as a member of the governing council of the International Zeolite Association.

Department ambassador Professor Alvin Weiss is also a long-time student of zeolite catalysis, and is widely recognized as a world-class expert. He has traveled all over the globe to share his expertise in catalysis, helping to set up projects or analyze results in Argentina, Israel, the USSR, and Viet Nam, among other countries.

Weiss's research projects in this area have been many. He has defined how ethylene glycol—the thick liquid alcohol used in antifreezes—can be produced as formaldehyde reacts over basic zeolites. He

also has been studying adsorption in natural zeolites.

A project that falls under the biochemical engineering umbrella involves using zeolites as one of a number of catalysts in the synthesis of edible sugars from non-edible chemicals such as formaldehyde. The sugars might also be synthesized from water and waste carbon dioxide—one small step toward making long space voyages more feasible.

One type of zeolites, the H-ZSM-5 synthetic, is a big player in the fuel industry, and Professor William Moser has been trying to find out more about it. Mobil has already used it to convert methanol to unleaded gasoline. It is used in South Africa in a process for converting coal first to synthetic gasoline and then to a readily usable gasoline. What Moser has found is that it can also be used to convert dilute aqueous ethanol to high quality ethylene.

"That means," Moser says, "using anything that can be fermented, you can take the alcohol from that fermentation and convert it to ethylene, which is probably the single largest commercial chemical used in the world. It's used for making everything from fuel to plastics." And since ethylene is usually obtained from either coal gas or petroleum hydrocarbons—finite resources—the option to take it instead from renewable sources like plants is a remarkable one.

Moser is joined in the study of zeolite synthesis by Ma and Thompson. Thompson devotes most of his research time to trying to understand how and under what circumstances zeolites crystallize. At present, a lot is known about what different zeolite crystals can do, but not enough about how they get that way, and without that understanding much of zeolite technology remains a dream rather than a reality.

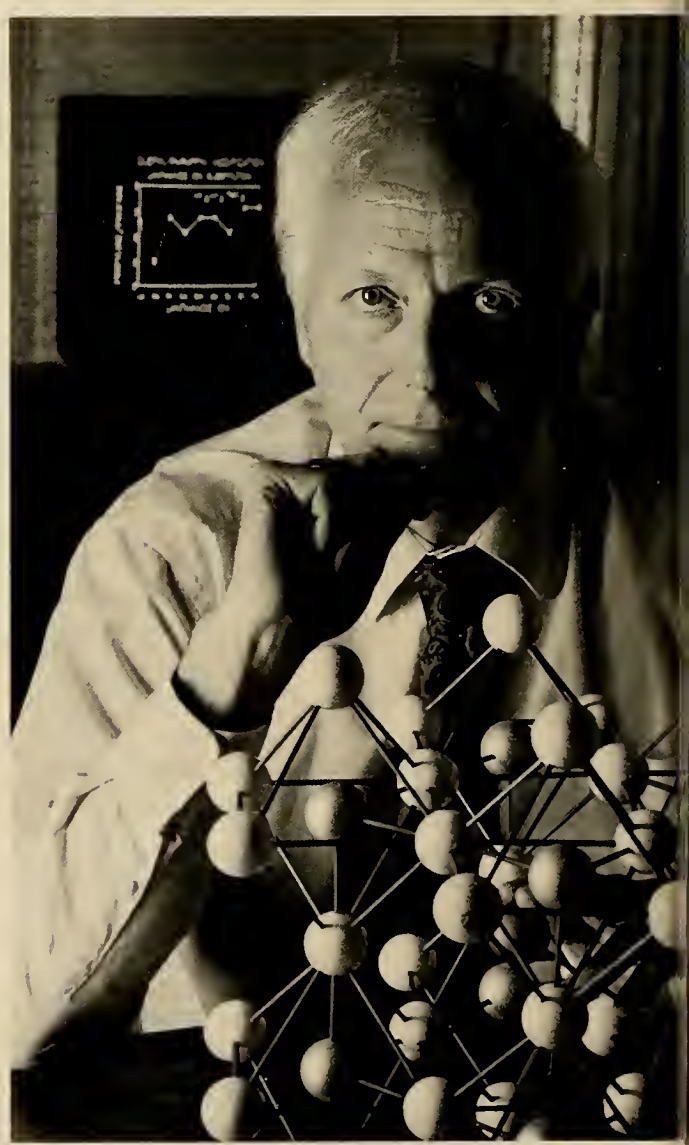
"Once we understand zeolite crystallization," Thompson says, "we can control it. Many of the natural zeolites come contaminated, and some of the synthetic ones are inefficient. Once we can control the crystallization process, zeolites should become much more cost effective."

Another problem Thompson is working on concerns zeolite stability—or lack thereof. Most of the useful zeolites are chemically unstable and tend toward more stable, but less useful, phases. Some zeolites can be stabilized in their useful phases, but the very substances that aid the stabilization have other side effects that botch reactions. Thompson hopes that, through both experimental and theoretical work, he'll soon be able to crack the mysteries of the transformation from one phase to the next and so, eventually, be able to control the change.

The project that the zeolite team is perhaps most excited about is the NASA space shuttle zeolite experiment. Thompson, Tony Dixon, and Associate Professor Albert Sacco have been awarded a $325,000 grant from NASA's Centers for Space Commercialization program. The team will study microgravity zeolite crystal growth—specifically, how to grow zeolite crystals in space that are larger than those that can be grown in earth's gravity.

On earth, Sacco explains, zeolite crystals of industrial interest typically grow to have sides two to eight microns (one micron is one millionth of a meter) in length. In space, where gravity becomes a secondary consideration and surface tension a primary one, the crystals may grow to have sides in excess of 100 microns in length.

Growing large zeolite crystals will have tremendous implications for the commercial use of zeolites. Such large zeolite crystals should



Prof. William R. Moser works on developing methods for using the alcohol from anything that can be fermented to make ethylene, the world's largest commercial chemical.

be excellent selective molecular membranes as well as useful ionic exchange materials. "NASA seems to think that this process may be commercialized in a short time," says Thompson. "But even if it isn't, we stand to learn a great deal about processing both in microgravity and on earth."

"We are one of probably only three or four schools in the country who know how to process in space," Sacco says. "In fact, we are perhaps the only school given priority flight time in the shuttle flight schedule." After the explosion of the *Challenger* delayed all subsequent shuttle launches, many experiments scheduled for the flights were bounced in favor of Department of Defense projects. But NASA thinks so highly of the WPI project that not only was a slot saved for it, but it was also actually bumped farther ahead of its original position on the experiment list.

While the NASA zeolite project's results should mainly benefit earthbound industry, Sacco's other NASA project may solve one of the major obstacles to extended space missions: the effort and cost of transporting oxygen from the earth. "Basically, we'll be mining the moon for oxygen," Sacco says, "and if it works, it should cost only about 20 percent of what it costs to transport oxygen from earth."

What Sacco is proposing is to mine ilmenite, a mineral composed of iron, titanium, and oxygen that's found in great quantities on the moon's surface. A fixed amount of hydrogen would be brought to the moon from earth and reacted with the ilmenite. As the hydrogen bonded with the oxygen in the ilmenite, water would be formed. The water then could be separated back into hydrogen and oxygen by electrolysis and the hydrogen recycled while the oxygen is used on a space station or for deep space missions. "Obviously, there are a lot of technical difficulties," says Sacco, "but we have a four-year contract to try to develop the kinetics of the process."

One of Sacco's graduate students, Randall Briggs '86, is continuing ilmenite-related

Michael Carroll

Current research of Assoc. Prof. Albert Sacco includes a NASA-sponsored study on the growing of zeolites in space.

Bob Wagner: Still Climbing All Kinds of Mountains

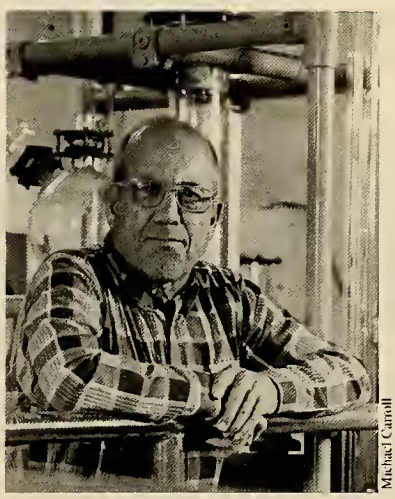
Before Prof. Robert Wagner and his wife, Ruth, set off on a cross-country retirement celebration last year, Wagner telephoned a few old students. By the time the couple returned to Shrewsbury, they had been welcomed into the homes of over 40 alums.

"It's funny," Wagner says, "but I remembered each of their voices the moment I heard it on the phone—even if I hadn't spoken to them since class 30 years ago."

Wagner has always had this instant rapport with his students, and it's a prime reason he has long been one of the best-loved professors on the Hill. Another is his ability to inspire his students with imaginative and practical approaches to problems that might at first seem outside the usual realm of the chemical engineer.

Wagner regularly used to supervise more than 30 MQP and IQP students a year, a measure of both his dedication and his popularity among the students. "I became a nature freak when I started mountain-climbing," says Wagner. "Since then, most of the MQPs and IQPs I've handled have centered around problems with the contamination of nature."

Solar composters at trailside toilets in the White Mountains posed a memorable puzzle for Wagner. Because they worked



Michael Carroll

too slowly, the Appalachian Mountain Club, which supervises them, faced the costly prospect of hauling wastes by helicopter. But Wagner's students found a way to enhance the composters' work by forcing warm moist air through their reaction chambers.

A paradox involving acid rain also riveted Wagner: Red spruce in valleys were healthy, but dying on mountaintops. His students designed a device separating clouds' particles of fine fog and rain. They solved the mystery: Analysis showed the fog particles to be 50 times more acidic than rain, and rain fell in the valleys while fog shrouded the peaks. The students next installed separators in Alaska and the Rockies under government contract.

"Chemical engineers are in the best shape to do this kind of environmental work," says Wagner. Thanks to his dedication, many WPI alums can now see why. —LB

research, which he began as an undergraduate while completing his Interactive Qualifying Project.

WPI'S NEWEST ADDITION to the chemical engineering team is Assistant Professor William M. Clark. Clark gained his Ph.D. from Rice University in 1984, then studied in Denmark for nine months on an NSF-NATO postdoctoral fellowship. Following further postdoctoral experience at the University of Delaware, he came to WPI last fall.

"Besides the high quality of WPI research and its students, I was attracted by the idea of working with DiBiasio and Rollings," says Clark. Associate Professors David DiBiasio and James Rollings form the backbone of WPI's biochemical engineering effort. The fact that WPI now has three researchers not only specializing in the field but also in different aspects of the field puts the college in a class by itself.

"There are probably not more than 80 biochemical engineers distributed throughout the nation's universities," explains Rollings. "Not more than 15 deparments have more than two people. We have three, which puts us among the, say, top five schools. And most of those have all their people working in the same area—fermentation, for example. Whereas at WPI, we have someone specializing in fermentation, in biothermodynamics, and in biopolymers."

DiBiasio is the department's point man in fermentation and process control of biochemical systems. Currently, his main area of concentration is in studying biochemical reactors, with an aim toward eventually controlling and optimizing them. The reactors DiBiasio is studying use whole cells, such as microorganisms or tissue cultures, to convert some raw material into a useful product. That product may be a protein, a vaccine, a hormone, or some other biological substance.

DiBiasio has spent most of his recent efforts on a microbial system yielding a protein that may be used for animal food. "I'm trying to develop a methodology for mathematical modeling of these systems," he says. These models, he hopes, may eventually be used to better control multiple steady state and dynamic reactors.

Hollow fiber reactors are a second kind of bioreactor used to produce proteins, in this case, proteins that may be used for therapeutic purposes. The problem is that since live animal cells are used to produce the proteins, special consideration has to be given to their fragility and their sensitivity to outside influences if the very biological processes that make them promising are to be preserved. DiBiasio is engaged in theoretical and experimental work directed toward designing these reactors so that the cells are maintained in optimum condition.

Even though many systems used in biotechnology research make use of immobilized cell reactors, not much is yet understood about how pinning the cells down affects their behavior. And without this information, it's tremendously difficult to predict how best to scale reactors

Michael Carroll

Biochemist William M. Clark is working to understand how fundamental areas of chemical engineering like thermodynamics and transport properties apply to new biochemical systems.

up to the sizes needed to make biotechnology a thriving industry.

So DiBiasio has formed a partnership with Judith Miller, associate professor of biology and biotechnology, to discover what effect immobilizing microbial cells in reactors has on a system. Miller and DiBiasio are studying a recombinant strain of *E. coli* to see how immobilization affects the cells' use of the input substance, distribution of by-products, and gene expression.

Two years ago, the National Science Foundation and the White House flagged Jim Rollings' exceptional work on biopolymers with a Presidential Young Investigator award. Proteins, polynucleic acids, and polysaccharides (carbohydrates such as starch or cellulose) are all biopolymers—biological substances whose molecules are constructed of chains of smaller molecules.

A polysaccharide, for instance, is a large molecule that can be broken down into component molecules such as fructose or glucose by breaking the hydrogen-oxygen bonds between these molecules. Rollings' work aims to build up an understanding of the fundamental physical and chemical properties of biopolymers and how these properties affect a variety of biochemical processes.

"Rice isn't corn isn't wheat isn't cassava, even though they're all polysaccharide starches," says Rollings, stating an observation that anyone who has either cooked with or eaten those foods will have made. "But why they're different, we don't know."

Not knowing why cassava starch was different from wheat starch didn't matter in the days when all that rode on that knowledge was a bowl of tapioca or a loaf of bread. But in the age of biotechnology, when these abundant, renewable sources of food may hold the keys to more plentiful supplies of fuel, industrial chemicals, or nutrition for people in food-poor areas, this knowledge becomes more valuable with every passing year.

One of the main facets of Rollings' research is the development of an analytical technique for characterizing biopolymers and their properties. Rollings has found that currently available tools for analyzing molecular characteristics aren't up to the task of studying biopolymer systems, so he's trying to come up with something designed specifically for them—a size exclusion chromatograph coupled to an on-line detector.

Another Rollings project is the study of depolymerization kinetics—what happens when biopolymers break down into their component molecules. "In industry, you want to process polymers so that they have more desirable end products," says Rollings. "For instance, you might want to take corn, which is abundant and cheap, and process it to come up with a sweetener that's cheaper than sugar cane."

What happens when a polysaccharide, for instance, is depolymerized is well known; it's hit with an enzyme and chewed down to its individual sugars. How that process works isn't understood, though. The practical problem of this lack of knowledge is that effective depolymerization usually boils down to a matter of trial and error attempts to break down some particular polymer. "So if we know how to get an alternative sweetener out of corn, that's great for places that have plenty of corn," says Rollings. "But what about Thailand, where cassava is the main starch crop? If we don't really understand depolymerization, the applications are limited."

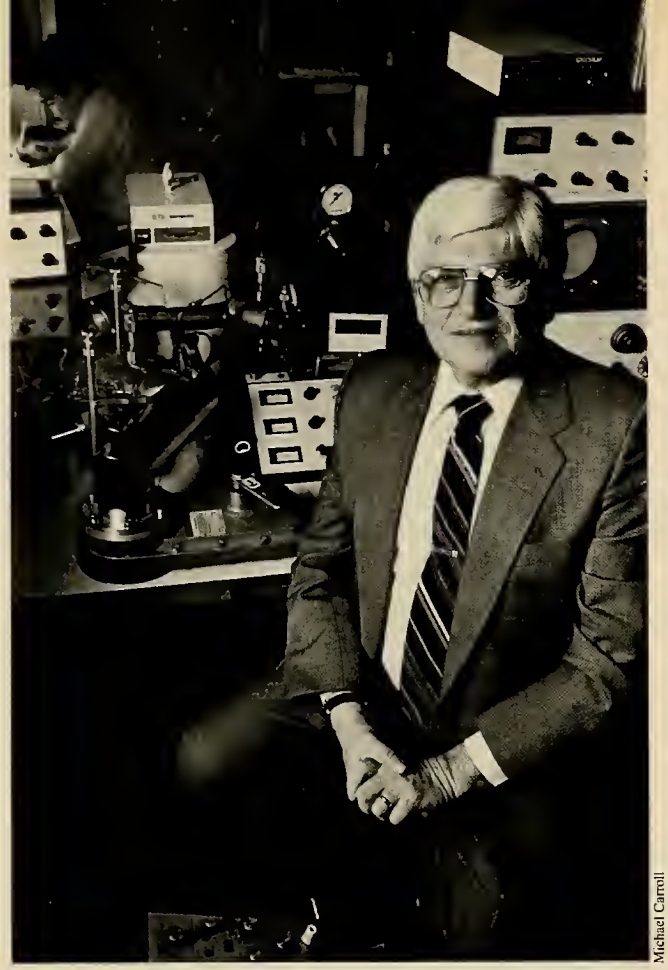
Michael Carroll

Assoc. Prof. David DiBiasio's research in biochemical systems centers on reactors that convert raw materials into products like proteins, vaccines, and hormones.

As the new kid on the block, Clark is still in the early stages of his research projects. But with a strong background in thermodynamics and transport properties, he is already in the thick of work geared toward an understanding of how these fundamental areas of chemical engineering apply to newly recognized biochemical systems.

One of the most important factors in the eventual survival and success of biotechnology as an industry is the development of reliable, large-scale recovery processes. It's all very well, after all, to be able to produce proteins or hormones or vaccines in the lab, but if you can't manage to extract them efficiently from the system they're in, they're not much use for anything except, perhaps, scientific study. So Clark is experimenting and using mathematical modeling to gain insight into some basic separation problems.

Clark's two main projects at the moment involve two-phase solutions. In the first project, he is studying the



Michael Carroll

Above: A founding member of WPI's zeolite team, Prof. Alvin H. Weiss also studies catalysis related to petrochemicals, ceramics, pollution control, and fire protection. Opposite: Assoc. Prof. Anthony Dixon (left) and graduate student Chue-San Yoo examine a semiconductor wafer.

thermodynamics of a separation process in which a bacterial cell pulls an antibiotic from one phase into the next, thereby separating it from the other components of its original solution phase. A kind of affinity partitioning, this process seems to have the potential to be very selective, even in a large-scale operation.

His second project is a collaboration with DiBiasio. They are trying to incorporate a two-phase system into a bioreactor with the hope that they can come up with an extremely efficient process—simultaneous biochemical reaction and extraction. (The experiment is similar to Rolling's reactor-separator experiments in concept, although the chemistry is different.) The idea is that, while recirculating the reactor cells and continuously removing reaction inhibitors and the end products, production of such things as antibiotics and recombinant proteins can be markedly enhanced.

WHILE WPI is at the leading edge of the two "new" specialty areas of zeolites and biochemical engineering, the department also claims honors as a leader in one of the field's most fundamental studies—catalysis. Most of the zeolite research actually falls into the catalysis category, but zeolites are just one in a myriad of catalyst types.

Weiss, a founding member of the zeolite team, together with Ed Ma, is also heavily involved in researching petrochemical catalysis, as well as catalysts for use with ceramics and in pollution abatement and fire protection.

He has been able to break down methane at high temperatures to produce acetylene and ethylene, immensely valuable chemicals which are usually taken from fossil fuels. Weiss has also invented a technique to fluidize silicon so that it can react with atmospheric nitrogen—a new way of manufacturing silicon nitride, a tough ceramic that is bound to be integral to new mechanical and electrical engineering design. And he has found catalysts that adsorb and react with toxic materials in ways that promise to save people from death by smoke inhalation—the primary cause of fatalities.

Catalysis falls into two main categories: heterogeneous (in which the catalyst is a solid and a gas or liquid reactant is passed over it) and homogeneous (in which the catalyst is dissolved in a solution and the reactant is passed through it). Over the last few years, chemical engineers have enormously increased their knowledge of how these two types of catalysis function, in large part thanks to scientists like Moser who have designed microscopic techniques for their study.

Over the past four years, Moser has developed a highly sensitive infrared spectroscopic exam that enables him to see what happens under typical industrial conditions. Using the exam, he has been able to determine exactly what happens—in real time and under real conditions—in the Monsanto acetic acid process (producing vinyl acetate, one of the top 10 industrial chemicals), the Union Carbide hydroformylation process (producing plastics and detergents), and the Dow organic halide carbonylation process (producing monomers for polymerization). "I'm providing the fundamental information needed to make these processes better," says Moser. "And if you make the processes better, you can make the products cheaper."

Moser's catalytic explorations have also led him into the development of a new method to synthesize simple and mixed metal oxides. This new method was meant to give the metal oxides unusual properties that would make them super-effective catalysts. But, unexpectedly, they also seem to be exceptional candidates for new leaders in superconductivity, the most recent area of engineering research to make the front pages. Moser is now doing the research necessary to determine if the materials' reality lives up to their potential.

In another case of near-serendipity, Al Sacco is now trying to encourage a stage of catalysis that he had previously spent years trying to eliminate. For decades, chemical engineers tried to stop the growth of the carbon filaments that tend to sprout whenever a catalytic process involves transition metals and high-temperature gases. As the filaments grow, they deactivate the catalyst, slowing down the process and

making it more expensive. But it turns out that if the filaments can be grown long enough and fat enough, they can be woven to make carbon-carbon composites that approach the strength of steel but are much lighter. Many supersonic fighter aircraft already use other types of carbon-carbon composites in their skins, and the material has many other potential uses in space and industrial design.

Tony Dixon takes information about catalysts and uses it to analyze and design catalytic reactors, in particular, the fixed bed reactor. "The fixed bed reactor is the work horse of the entire chemical industry," according to Dixon. "The bulk of all chemical processes comes through these reactors, and the efficient operation of the reactor is dependent upon an understanding of the heat transfer process within it. That's what I'm working on."

One way to think of a fixed bed reactor is to think of a tube filled with catalytic particles and perhaps other reactants. The primary reactant is passed through the tube. As it comes through, the reaction produces a lot of heat, usually enough to burn up some of the products that are supposed to emerge at the other end of the tube. The goal is to get as many of those products to come through the tube unscathed as possible.

What Dixon is studying is the relationship between the rates of heat transfer and the flow of gas through the tube, with the ultimate aim of being to be able to control the amount of damage done by the heat. Dixon is experimenting with how different catalyst particle shapes and methods of packing the tube come into play.

THE PAST FEW YEARS have been eventful ones for the Chemical Engineering Department. In addition to the many honors collected by individual team members, the department and the college have garnered attention as home of the New England Biotechnology Association (NEBA), organized by DiBiasio, Rollings, and Judy Miller to promote dialogue between people specializing in biotechnology, biochemistry, and chemical engineering. This year saw the fourth annual NEBA conference held at WPI, with more than 200 university and industry scientists and engineers in attendance.

In addition, Sacco and Weiss were chosen as this year's co-chairmen for the 18th Biennial Conference on Carbon which took place at WPI in July. This is the largest U.S. conference of its kind. More than 600 carbon specialists from around the world attended and presented over 300 papers.

WPI has traditionally been known as a leading center for the study and teaching of chemical engineering's fundamental disciplines—thermodynamics, fluid mechanics, process engineering, and the like. Even though the department has established itself as a leader in novel areas, that hasn't changed.

Anthony Dixon's advice to young chemical engineers hasn't changed with the opening of new frontiers: "We need the specialty areas, but we still need what we think of as a chemical engineer's basic knowledge. That's where we come from, and that's what enables us to make our unique contributions in new areas."

Leslie Brunetta is a case writer at Harvard's Kennedy School of Government and a freelance writer and editor.

Michael Carroll

Michael Carroll

The Entrepreneurial Spirit
Seventh in a Series

Room with a View

From his office overlooking the nation's premier hi-tech highway, Fred Molinari '63 looks at the past and, especially, the future.

By Michael Shanley

Fred Molinari fits the classic profile of an entrepreneur, but don't tell him that.

The founder and president of the computer product firm Data Translation considers such profiles to be largely irrelevant.

"People try to find similar characteristics among entrepreneurs," says Molinari from his company's modern all-purpose headquarters on Interstate 495 in Marlboro, MA. "And they do find some things. They find that entrepreneurs are likely to be 30 to 35 when they start businesses, that they probably were firstborn of the family. But you could get together a lot of people who are 30 to 35 and firstborn in the family, and there probably wouldn't be an entrepreneur in the bunch. And if you got together 50 entrepreneurs, you'd find 50 different stories."

Molinari's story, however, has at least some familiar elements. Like other of the industry's success stories, Molinari found himself a niche in the growing computer industry of the early 1970s and rode the wave as the world embraced low-cost computing power.

Molinari's niche was—and is—data acquisition products, devices that take information from electronic sensors (which measure such things as temperature, pressure, and voltage) and translate them into digital form for storage or processing by computer.

"There's a fundamental need to convert analog to digital," Molinari explains. "Some companies do it with an integrated circuit, or chip, and others, like us, do it in a modular sense."

Molinari cites the common industrial application of a process control loop, where precise temperature measurements are crucial.

But Data's devices are also used in a variety of other settings. In medicine, for example, the company's products are used as a go-between for Jarvik artificial heart patients and their computer monitors, and as part of the process for "cell sorting," a noninvasive technique for studying the human fetus. Another company uses one of Data's boards as part of a noise cancellation system that makes factories and vehicles quieter and more vibration-free.

Most of Data Translation's products, which generally range in price from $500 to $1,500, are made for Digital Equipment Corp. computers, but the company is also the principal supplier of data acquisition products for the IBM PC.

In recent years, Molinari has overseen the company's expansion into the field of image processing, which converts a regular picture into digitized form and stores it in the computer. One of Data's image processing boards allows an image from a camera or VCR to be stored as data in a computer's memory, then displayed on a computer monitor.

A new generation of boards and software that offers sharp resolution and extremely fast flexible processing has doubled and tripled the company's growth in the last year or two. Data's products are being used to solve problems in research installations, factories, X-ray equipment, and CAT scanners.

CSD International Inc. is using one of Data's image processing boards as part of an automated system that inspects toothbrushes. A video camera takes a picture of the toothbrush, then the digitized picture is examined for defects such as missing tufts or dirt.

All this pushed Data's net sales over the $23 million mark last year, a 37 percent increase over the previous year. Net income was $2.1 million, an increase of 30 percent. Stock originally priced at $7.50 when the company went public in 1985 was selling this summer at $17 to $18 per share.

The company's sleek 47,000-square-foot Marlboro headquarters has been expanded four times. Construction on another 30,000-square-foot expansion will soon be under way. Data currently employs about 175 workers. Included among the 25 engineers are several WPI graduates, including Stephen G. LaVeuenesse '84 and Robert F. White '64.

But, of course, it wasn't always so rosy for him. Like most who have built companies from scratch, he's been through some hard times. Foremost among them was a devastating trade secrets suit that nearly destroyed Data Translation in its first months of operation.

That's why when you ask Molinari today what the one crucial ingredient in the entrepreneurial soup is, he'll say "perseverance."

"Almost anyone can make it, given the time," he says. "You just have to have enough determination to make it through the difficult years. That's assuming that you know what you're doing, and that you're going to pick up on opportunities and keep going.

"Luck plays a big part, too—you can get there earlier if you have some lucky breaks. But even without the breaks, it's just a matter of being solid in your commitment to what you're trying to do. Of course you've also got to be smart enough to figure out something that really makes sense to do, and perceptive enough to know when it's time to move in another direction.

"Each venture has its own fingerprints. But I think the overriding element is perseverance." Molinari's own perseverance was severely tested early in his career.

After working for a few years as a manager for Pacific Telephone and Telegraph in San Jose, Calif., and as a design engineer for EG&G at a nuclear test site in Nevada, Molinari returned to New England. He took a job as an electronics engineer while earning a master's degree in electrical engineering from Northeastern University. A number of business course electives there fueled his interest in marketing.

He was accepted into Harvard Business School, and studied full time for a couple of years, earning an M.B.A. in 1970. To help pay his way, he took consulting jobs with a company called Analog Devices.

After graduation, he went to work for Analog as an integrated circuit/converter product marketing manager. Two years later, he accepted a vice presidency at a similarly named company, Analogic Corp. Both companies were involved in translating analog into digital.

"I ended up having some fundamental differences of opinion with my boss," Molinari says of his one-year stint with Analogic. "And of course I was the one who had to go."

So, in 1973, Molinari—with a wife and three children, little in the way of savings, and lots in the way of expenses—found himself out of work.

"I did what many out-of-work people do," he says with a smile, "I called myself a consultant."

On a more serious note, Molinari says, "So much of life is determined by how you deal with unforeseen events. I think people get the mistaken impression that every entrepreneur has a master plan to start his or her own business and be successful. Perhaps that's true in some cases, but it wasn't in mine." In fact, Molinari says, he was quite happy working for somebody else.

Michael Carroll

Assembling advanced computer hardware is still a labor-intensive task. But automation, says Fred Molinari '63, is replacing much of the painstaking effort involved.

Over the course of his time at Analogic, Molinari had established enough contacts to make a decent living as a consultant after parting ways with the company. "I never really liked consulting, though," Molinari recalls. "Because you're always trying to sell yourself—it's 25 percent doing your job and 75 percent selling yourself. And you're always looking for the next job."

While on the consulting circuit, Molinari met two others with similar situations. "We had different skills," he says of the men who would become his partners, "and we were able to put something together."

All three had an understanding of the data acquisition field, so they each tossed $700 into the pot and, in November of 1973, formed Data Translation.

After a few weeks of working out of the basement in Molinari's Framingham home, they found a low-rent, 9-by-12 office in town. There—below a bowling alley and above a restaurant—they developed their first product, a data acquisition module similar to products sold by Analogic.

"We succeeded in the most important step in any venture: we started," says Molinari. It's like the answer to the question 'How does one begin running?' 'You open the front door, and you put one foot in front of the other and you keep going.' That's what we did."

The first months were spent writing data sheets, buying printed circuit boards and components, and preparing a business plan that could be shown to venture capitalists. The trio supported themselves by consulting for other companies.

Just four months into the venture,

catastrophe struck. Before the product was even on the market, Analogic slapped the new company with a lawsuit, claiming, on the basis of a data sheet, that Data was unfairly using Analogic's trade secrets.

"Here we were without any income, without a product and without any funding, and a court suit we were totally unprepared to fight. None of us had even been in a courtroom before."

Worst of all, Molinari explains, was what happened to their fund-raising efforts: Lawsuits are the kiss of death for start-up companies seeking venture capital. "Venture capitalists won't invest their money in a business whose time and energy are tied up with legal troubles."

In fact, Molinari says lawsuits are a routine weapon used by established companies like Analogic to squash new competition.

"They said we took trade secrets," begins Molinari, warming up to a heartfelt indictment of the legal system. "But they wouldn't say what the secrets were. How were we supposed to fight that? The more nebulous a lawsuit is, the tougher it is to defend yourself, because there's nothing to take issue with."

One major software maker, he notes, is now suing other software developers, saying the new software "has the look and feel" of its popular spreadsheet program. "What does that mean? How can you defend against that?

"As every American knows, if you've got enough money and enough clout, you can tie things up in the court system forever. In some cases, the little guy ends up winning, but he's injured himself so badly in the process he can't recover. As the case drags on and on, there's no money coming in for the little guy—it's the quickest way to put him out of business.

"It happens every day in technology cases. That's one of the ways that this country discourages entrepreneurship. People think it's encouraged, but it's not. The whole legal system is against the entrepreneur—the entrepreneur succeeds in spite of it, because of commitment and perseverance."

Molinari sweeps his hand to take in some of the other hi-tech giants in Marlboro's industrial park. "They've all got lawsuits going against small companies. A judge doesn't know anything about these technical matters, so the only way to proceed is to hear deliberations. That can take years. And the big companies are never penalized for frivolous lawsuits.

"In Japan, this doesn't exist. They have 15,000 lawyers versus something like 700,000 in the United States. That means they have a legal establishment equal to just 2 percent of ours."

Molinari believes that trade secret suits should be virtually eliminated in this country, since only a tiny percentage, he says, are valid.

> "We succeeded in the most important step in any venture: We started."

When, after two and a half years, Data Translation finally lost its case to Analogic, Molinari considered it a victory. "We finally had them off our backs and could get going. We never even knew what the trade secret was—it was the 'look and feel' issue again."

In the early days of the lawsuit, one of Molinari's partners bailed out. "Interestingly, he was studying to be a lawyer at the time," says Molinari with a smile. "Maybe he knew things we didn't know."

By the end of the legal proceedings, Molinari and his partner had slowly built up enough of a business to pay off the $56,000 judgment against them. Their legal fees exceeded the settlement, however. "Luckily, the owner of the law firm had a hunch that we'd be successful, so he took stock instead of cash." Today, the lawyer is one of Data Translation's largest stockholders.

"There are times to cut everything to the bone," says Molinari, "times to just do the best job you can with what's available. That's what we did through those first couple of years.

"But you've also got to know when it's time to really spend money, when the market is ready for the right product. For us, that time came in 1976, when a few large computer companies started bringing out single printed circuit board microcomputers. This was one of the turning points in the computer industry. It brought the costs way down and made more people aware of computing capability. We quickly came out with a line of data acquisition boards that fit nicely with these computers."

Sales built dramatically.

And when the next computer revolution, the personal computer, arrived, Data Translation was ready for that, too.

The rest, of course, is simple history. It's as simple as the sleek new buildings that line Routes 128 and 495 in Massachusetts and Silicon Valley in California. As simple as the millions of computers that are now so much a part of our lives. Fred Molinari's boards are housed in a good chunk of those computers, and that's a lot of merchandise.

Over the years, the company, searching for a new and bigger home, moved to Natick and, finally, to Marlboro.

But, as the company grew, Molinari's own focus narrowed. No longer required to be a jack-of-all-trades, he was free for a little crystal ball gazing.

"The job of any head guy," he says, "is to figure out what the company is going to be doing two or three years from now. You always have to be living in the future. So what you have to do is unload the day-to-day operational responsibilities and keep looking farther and farther into the future."

What he sees is bright enough to require shades.

You may think we must be close to reaching the saturation point with computers, but Molinari doesn't. "We're nowhere near the end. Computers are going to be used more and more. And everywhere automation takes place, they'll be using our products."

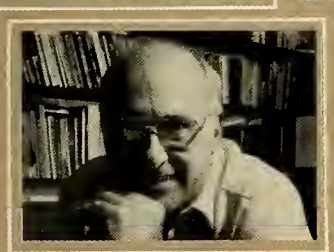
International economics are such these days that to ensure the quality that consumers demand, industry can't rely on the human eye and hand anymore, Molinari says. "You've got to have computers bringing things together now, you've got to have robots. And our image processing boards are eyes for robots."

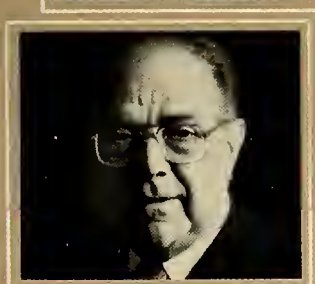
Molinari ticks off the examples, from automobiles to dental systems to soft drink manufacturing. The message is clear: Data has only just begun.

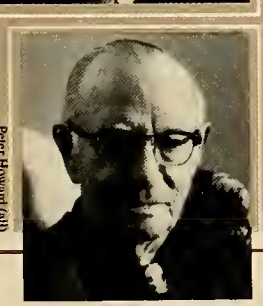
Yet Molinari knows that future business won't be delivered to him on a silver platter. Past successes are worth little in a world full of hungry young companies such as Data once was.

"You have to stay ahead of the mar-

Continued on inside back cover







Peter Howard (all)

An Album on Aging

Essays, portraits, plain facts, demographics, and even the quirks and quackery of growing older. Here's a summer anthology on the passage of time in our lives, from middle age onward.

A mirror on the middle years

Reflections on remapping life 25 years after graduation

By John T. Bethell

"MIDDLE AGE," wrote Ogden Nash, "is when you've met so many people that every new person you meet reminds you of someone else." A contemporary greeting card pilfers Nash's line and tacks on, "Old age is when no one you meet seems familiar!"

Or words to that effect. I'd check it, but I can't remember where I saw that card.

Certain departments of my brain, alas, have elected not to wait for old age to begin forgetting things I could always remember: people's names, the second law of thermodynamics, what Mike Andrews hit in the '67 World Series, and high-impact intellectual words like *heuristic* and *teleology*.

And that isn't the only dismaying aspect of middle-aging.

In the country of the middle-aged, our circle of professional retainers inexorably expands to include endodontists and periodontists as prominent members of the support team. Peering into a store window we see reflected an ample forehead and deeply etched crow's-feet that must be someone else's. They are ours. We can't stay up as late as we used to, and we need more recovery time after going running. In fact we need more recovery time after *everything*. When we dine out we begin with Perrier, and after the meal we order decaf. With increasing frequency we discover the names of classmates in the obituary column of our college magazine. Many of us have lost one or both of our parents. Some have lost children.

So much for the bad news. The better news is that, despite our declining physical prowess, most of us still have energy in abundance. Experience has endowed us with an understanding of the complex dynamics of change and a sense of How Things Get Done. Under the lengthening shadow of mortality we have learned to use time better, to be more purposeful. ("As we advance in life, we acquire a keener sense of the value of time," wrote William Hazlitt in 1827. "Nothing else, indeed, seems of any consequence; and we become misers in this respect.") But we also derive satisfaction from sharing our knowledge and skills—with our children, who may not appreciate what we have to offer, and with younger coworkers, who may. As the children leave home we rearrange the furniture of our lives to create more space for intimate relationships and for social concerns. We grow more generous and accepting of people's shortcomings, including our own. We learn to read from our own biographies, and to put what we read to use as we remap the balance of our lives. Middle age is by no means all bad. As Daniel Levinson writes in *The Seasons of a Man's Life* (1982), "The concrete character of adult life is one of the best-kept secrets in our society, and probably in human history generally."

For those of us who are 25 or 30 years out of college, a class reunion provides a panoramic grand tour of the country of the middle-aged. This summer at my own university's commencement, I mixed for a while with returning members of the Class of 1962 (which describes itself retrospectively as "The Last Polite Class" in the history of the institution). I am not a member of the class—I was born eight years too soon for that—but my brother is, and so are a number of friends. In the course of their five-day reunion I went to a thoughtful symposium titled "Safe at Last (?!) in the Middle Years," compared notes on aging with a variety of experienced hands, and skimmed through the buckram-bound *25th Anniversary Report*, which at 999 pages is longer than John Barth's longest novel. It teems with raw data, case histories, and apercus served up by members of this 1,160-man class, and like previous 25th reunion reports, it may constitute an invaluable resource for future contributors to the growing scholarly literature on the nature of mid-life. (It's unfortunate that most of the existing literature is male oriented, but that is starting to change.)

"What amazes me is the way we all seem to be aging in lockstep," one reunioner told me. Leafing through autobiographies in the *Report*, you are struck by the reiteration of shared concerns, of common perspectives derived from diverse experience.

The theme of mortality overarches everything. "I'm getting paid to have fun," writes a Boston investment banker, but:

> All is not joy and computers. My father died four years ago; my mother died this month. A close friend drowned recently. Death is no longer impossible. I had bleeding ulcers six years ago. I don't take alcohol, nicotine, aspirin, or coffee. I also know a lot more about stress and how to handle it. Mid-life crises are not just a psychologist's invention; we all have them. Some have better ones than others. I'm not through with mine yet.

A Chicago lawyer writes:

> My father died [in] January in his eightieth year. It made me see things differently. Whereas I had always

JOHN GARTLAND, AGE 47

"You never know what's going to happen. There is no career path."

"Hubert Humphrey once said that the longer he stayed in the Senate, the better seniority looked. As you get older, the older people are, the better they look. Once you'd think, 'Oh my gosh, 60, that's over the hill.' Now you say, 'No, I'm just ready for another career.' "

John Gartland's career has taken unexpected turns, thanks to the success of Republican candidates. When he graduated from Villanova University in 1963, he expected to go into business, but was swept up in a victorious Nixon campaign. At 47, he is content to be a corporate lobbyist and volunteer "advance man" for President Reagan, arranging details for his trips abroad. But he delights in the thought that his future may turn on an election, a phone call, or a chance meeting: "You never know what's going to happen. There is no career path."

Age is no disadvantage in a city where contacts determine power. "The lobbyist's point of view is the older you are, the longer you've been in it, the more influence you have," he notes. Gartland's office, filled with official thank-yous, certificates, and photographs of presidents, is a memorial to two decades of work in Washington.

He believes that fewer Americans consider 65 the "magic year" when careers end and carefree days begin.

"I think the bloom has really come off the rose. I think my parents, and people in their age bracket, were taught, 'You're going to retire at 59 or 60, you're not going to do anything, and you're going to go off to this great, wonderful life.' But we have seen, taking care of our parents, that it's not that great.

"I am not looking for that day of retirement. Yes, when I reach 60, and my last child is in the class of 2000, then I will be a lot freer to do more of what I want to do. It may be what I'm doing right now. But I'm not looking for retirement, I'm looking for doing a different career."

Profiles by Julia Ridgely

Photographs by Peter Howard

CAROLYN SCOTT, AGE 41

"For me, the best age is the age that I'm at."

"Who would want to stay 22 all their lives? To stay in any one area would be boring, like living in a climate where there's no change of season."

Carolyn Scott tends her garden in the farmlands outside Westminster, Md., few miles from her alma mater, Western Maryland College. One of her recent large-scale projects was advising the College on the renovation of the McDaniel Lounge and its gardens.

The seasons of life are longer than of those in her backyard, and her summer longest of all. "I see life as proceeding in double decades. I see 40 to 60 as really getting in the beat of life. Even 60 to 80 I think is really just getting into the swing of things. Eighty may be old, but ask me again when I'm 80."

For ease of living, she gives a slight edge to the post-30 years: "It is a more comfortable time materially." But she adds, "For me, the best age is the age that I'm at. I hope I change my mind next year when I'm 42."

She is looking forward to the empty nest syndrome and the time to pursue less earthy interests like writing and photography, and she will probably not stop there.

"It takes me so long to learn so little. I'll be old when I stop learning and stop growing."

looked forwards in my life, and up, suddenly I stood at the end and looked backwards, to where I am now, and towards the beginnings. . . . Although it should undoubtedly have been old news, it came as a shock to me to realize there are perhaps 25 more good years—if I'm as lucky as he was. Twenty-five years back, and 25 years forward; a good time for a reunion report. Mid-life, mid-career, mid-kids, mid-everything.

And this from the attorney general of a Pacific Northwest state:

> The unabated joys of parenthood were shattered three years ago when [my wife] and I learned that our two beautiful, bright and cheerful daughters both are hostage to a biological time bomb. Fanconi anemia, a lethal disorder characterized by bone marrow failure, strikes most often (in our case totally by surprise) in the first decade of a child's life. . . .We are told that only a bone marrow transplant, for which we have no suitable family donor, can really promise significant life-extending possibilities.

The authors of these accounts are resilient survivors, capable of extraordinary forthrightness and humility. "I have been drowned, poisoned, and rearranged my face on a post, which I met at full sprint," writes a California designer and environmentalist who comes from an old Boston family. He adds, "The truth of Zen lies somewhere within that space between utter joy and excruciating pain, and I shall be the better for it. . . ."

The current life of a New York state attorney reflects what Alfred North Whitehead called the disorderly character of experience. The lawyer writes:

> I am in at least four "stages of development" at once. My children from a previous marriage are 21, 19, 17, and 15. Barbara and I now have our own baby, born October 1, 1985. My oldest son . . . has just announced that I will be a grandfather. . . . Finally, my 80-year-old father, having retired as a judge, practices law in my office and, when I sometimes find him napping in the afternoon, I feel more like a father than a son. Am I young? Am I old? Or am I just right? . . . I feel that life, although seldom easy, has given me an unexpected second chance for personal happiness.

"Sometimes I wish life would relent," admits a visiting professor of education at a major private university. "Then I look around at us in wonder: If this is the price of admission, I'll gladly pay." His concluding sentence is: "As I get older, I'm more patient about everything but complacency."

This *Bildungsroman* of middle life contains few signs of complacency. There are many expressions of willingness to acknowledge and accept failure, but that is not the same thing. Here is one, from a geophysicist:

> I work largely on the physics of the terrestrial and Venusian stratospheres, my latest effort being a speculation on the origin of the great Antarctic ozone hole. At this writing, it appears to be wrong.

A Massachusetts teacher rejoices in "the giddy happiness of my second marriage," but goes on:

> I consider my life in nearly every other respect a failure. It is pretty clear now—even I can see it—that I'll never pitch in a World Series. . . . What remains and matters are several friends . . . and this bewildering 10-year ecstasy with Sandy.

Many accounts illuminate a process that Levinson calls "reworking the dream." Henry Thoreau, an early student of life cycles, described it in this way: "The youth gets together his materials to build a bridge to the moon, or, perchance, a bridge or temple on the earth, and, at length, the middle-aged man concludes to build a woodshed with them." An upstate New York university English teacher—another who resorts to baseball for a metaphor—writes:

> Here I do everything but lit . . . which is my chosen career. But they have to play me because I am tenured, through a series of misadventures illustrating that justice gets out of town as often as possible on weekends; and so I am a lifetime utility infielder in a department needing a .320 Shakespearean and a good southpaw deconstructionist.

For some, processes of self-renewal have become continual. Writes a Massachusetts consultant:

> In a way there's a pattern—do things that are interesting and new. . . . The problems or opportunities [of management consulting] keep changing as do the groups. Rarely dull. The rest just sort of happens, gets intense, and then integrates and finds its place. There was a time of running and marathons, a time of yoga and reflection. Now it's a plane and flying.

We could go on and on. But let a California writer and actor have the last word:

> Currently, I am happily married. But I haven't found God or mastered the PC. However, I feel that Jesus and IBM are coming soon.
>
> Suffice it to say that I've spent the past 25 years "finding myself." Now, I plan to spend the next 25 playing with what I've found.
>
> So much for life. I congratulate the survivors. Now, where's the party?!

When I finished this *omnium-gatherum* of confessional literature, I reread my own submissions to the 25th and 30th reunion reports of the Class of 1954. Because I was not at ease in first-person writing, I had adopted a parodic self-interview format for these reports. "What, another reunion?" I began rhetorically when I wrote in 1984.

> *Time marches on, old sport.*
> Indeed. And the fractile effects of its passage seem more evident now than they did five years ago.
>
> *How would you characterize yourself at this point?*
> On the sill of age.
>
> *A phrase you pinched from Robert Fitzgerald's translation of* The Odyssey, *did you not?*
> I might have.
>
> *What preoccupies you at present?*
> Mourning lost innocence. Not mine. Everybody's.
>
> *Can you think of anything to be bullish about?*
> Word processing! Bach, Haydn, Mozart, Schubert, Brahms. My wife's smile. In point of fact I've been lucky.
>
> *Say something about the future.*
> Come the next reunion, I hope to have seen two of my three offspring into and out of college, run a few more marathons, and read all the novels of Dickens.
>
> *And after that?*
> A happy retirement, in Cloud-Cuckoo Land.

I regret writing "fractile" and that mawkish bit about innocence. As to the rest, the college projections are on target. The marathons are behind schedule, but there is time yet. Halfway through *Little Dorrit* as I write this, I still have *Great Expectations*, *A Tale of Two Cities*, *Our Mutual Friend*, and *The Mystery of Edwin Drood* to savor before starting all over with *The Pickwick Papers*. A wonderful novel, by a very young author, about a middle-aged man and his friends.

John T. Bethell is editor of Harvard Magazine. *He took up competitive running at the age of 45 and has since completed 127 road races, including six marathons.*

Lifestyle, illness,

'Use it or lose it' often turns out to be good advice for both body and mind. Many physical changes are simply a part of aging, but others may signal disease.

By Peggy Eastman
Photos by
William Denison

The alert mind can be honed well into old age. What many call senility could be a temporary lapse in memory related to stress.

It starts with small things: a crinkly relief map at the outer corner of the eyes, a graying that spreads from the temples to the crown, an inability to remember just where those car keys went. We think to ourselves, "I must be getting old."

We all age, but at our own pace. People don't experience clockwork-timed changes that say now you're 50, now you're 60, now it's time to retire. One person might have the equivalent of a 70-year-old heart in a 50-year-old body. Conversely, Jane Fonda in her early 50s seems to maintain the physique of a woman of 40. "There are extraordinarily 'young' 80-year-olds, along with extraordinarily 'old' 40-year-olds," noted one study of 1,000 volunteers over a 23-year period. Known as the Baltimore Longitudinal Study of Aging (BLSA), this project began by looking at healthy men aged 17 to 96 (women were added to the study about a decade ago). So far, it has found far more physical, mental, and emotional differences among a group of randomly selected people over 65 than among a group of younger adults.

But in the field of gerontology, such studies are rather rare, for it is a specialty in its youth. The National Institute on Aging (NIA) was not even established until 1974.

"The state of research on aging is quite primitive—yet aging could turn out to be far more complex than cancer," notes Rene J. Herrera, a Worcester Polytechnic Institute (WPI) biotechnology professor who is attempting to unlock secrets of aging on a cellular level. Two factors spurring more basic research, he explains, are "the scientific realization that we know so little about aging, plus the political realization that the percentage of people in the aging brackets is increasing—and all of these people still will have the right to vote."

In recent years, this escalation in the numbers of elderly has prompted a far higher priority on treating age-related maladies. Health care professionals can, for instance, unblock or detour clogged arteries, replace arthritically crippled finger joints with synthetic implants, and train the incontinent to achieve better muscle control.

In sorting out what is normal aging and what is abnormal, medical professionals are shedding light on how the lifestyle choices we make affect our longevity. Wellness programs and preventive medicine emphasize personal decision making in balancing risks, although there is plenty of conflicting evidence to make such decisions bewildering at times.

In general, normal aging may be viewed as a loss of adaptation to the environment, suggests J. Grimley Evans, a physician specializing in geriatric medicine in Oxford, England. Men and women in their 70s, even when not suffering from disease, still will not be able to run as fast, see as clearly, or hear as acutely as they did at age 25. Reaction times and reflexes slow down. "You're not as likely to get your hand out, so you fall over and break your hip," he adds. He proposes setting up physical training programs to help the elderly improve their protective responses.

Many individuals later in life experience a sense of losing control of their lives, which all too often turns into learned helplessness, notes Dr. John Campbell, professor of psychology at Franklin and Marshall College. "They develop the expectancy that they cannot control outcomes, and so they don't even try." They will tell themselves that they did poorly at a task because they have a terrible memory, when the fault might be elsewhere. One approach to help overcome this is "giving people situations they can control" to build up their confidence.

Exercise and diet can modify—but not entirely block—the changes the body undergoes in aging. From BLSA data, for example, we know that the propor-

and longevity

tion of lean body mass (muscle tissue) to total body weight drops with age, while the percentage of fat increases. What other physiological changes are normal?

As we add on years, we often add on weight. But for the obese, it's better to be shaped like a pear than to have a pot belly.

Old bones and new tissue

In aging, the body's framework of 206 bones loses density, especially in postmenopausal women. Bone is far from dead: It is living tissue in a constant state of recycling. Breakdown cells called osteoclasts destroy old bone so that it can be reabsorbed into the body, while osteoblasts help to build new bone tissue. Bones no longer lengthen after the body has reached its full height, but the remodeling process must continue for bones to be strong, dense, and healthy. When more bone tissue is lost than replaced, osteoporosis—the brittle bone disease—results. Women with osteoporosis (often with the characteristic "dowager's hump") become stooped over as their weakened vertebrae collapse and their bones break easily. More than half of American women over age 45 will experience osteoporosis, as will 90 percent of those over age 75.

Heart and blood vessels

As changes occur in muscle mass and the skeletal framework, the heart and circulatory system gradually decline from their maximum aerobic potential. In practical terms, healthy, well-conditioned 65-year-olds may still be able to play a good game of singles tennis, but they may tire after one or two sets rather than the three in a row they had played 20 years before.

Chronological age doesn't predict heart function, but the cardiovascular system does exhibit age-related changes. Among them are a stiffening of arteries, hardening of the aorta, and impairment of the ventricles' capacity to relax after pumping blood, notes Nanette K. Wenger of the Emory University School of Medicine. Older people are more likely to experience severe atherosclerosis, ultimately leading to heart attacks and strokes. Both chronic high blood pressure and the low pressure that causes faintness (orthostatic hypotension) often become more severe in older people.

Older and wiser?

A sharp intellect can be honed and exercised well into old age. But the performance of older people on tests measuring verbal learning and memory tends to decline, especially if such tests are given at a fast pace, the Baltimore longitudinal study shows. Its authors theorize that each passing year may result in a slightly lowered performance, or that some threshold level of decline in the brain has to be reached, or that a milestone event must occur (such as worsening of atherosclerosis) before the lowered level of intellectual performance is noticed.

For those who continue to pursue intellectually stimulating activities, these changes in the brain's physiology may be so subtle that they are hardly recognized.

Forgetfulness and senility

Senility, far from inevitable, too often is a "wastebasket" diagnosis, in the words of Robert N. Butler, former director of the Washington, D.C.-based NIA. True senility is a disease resulting from a progressive loss of brain cells, which can never be replaced. What many call senility might more accurately be termed a temporary lapse in memory.

"We use the term 'benign senescent forgetfulness' to discriminate between ordinary forgetfulness and organic brain disease," says May L. Wykle, acting director of the Center on Aging and Health at Case Western Reserve University, where she's also professor of psychiatric mental health nursing at the Frances Payne Bolton School of Nursing. "Benign senescent forgetfulness is common after the late 40s, although peo-

Staying actively involved gives you an edge later on. Regular exercise can help to modify some physiological changes of aging.

ple complain of it earlier than that. It means forgetting where you put your glasses, forgetting the names of people you run into, parking your car and getting panicked because there are so many cars out there in the lot and you can't remember where yours is."

Those kinds of lapses may be a reaction to "life overload." Bit by bit, we seem to get too much information, too much complexity, too much responsibility, says Wykle. "This is part of normal stress. As you get older, you have many more things to do. People get panicky because they think it's Alzheimer's disease, but it probably isn't."

One of the most publicized forms of dementia, Alzheimer's disease now afflicts an estimated 1.5 million Americans severely, 1 to 5 million moderately. By the year 2000, the number of Alzheimer's patients is expected to jump 60 percent.

Physicians aren't sure of its causes, although evidence is mounting for an infectious virus and some kind of genetic trigger. One theory points to an abnormality on chromosome 21 as a cause of both Down's syndrome and Alzheimer's disease. In fact, almost all people with Down's syndrome who live past 40 develop Alzheimer's disease. Other theories blame as a key factor an injury to the blood-brain barrier, thus permitting harmful substances to enter the brain.

Another promising clue about the cause of Alzheimer's disease comes from research into amyloid, a "marker" protein found abundantly in the brains of Alzheimer's patients—and in those of aging monkeys, apes, dogs, and polar bears. Amyloid is linked to distinctive, abnormal clusters of nerve cells. While nonhuman mammals don't develop Alzheimer's disease, those with heavy concentrations of amyloid show memory loss and some behavioral changes (such as confusion) similar to those in human patients. "This similarity in amyloid levels provides a strong biochemical connection with which to investigate the biological basis for memory impairment," explains Donald L. Price, director of the Johns Hopkins University Alzheimer's Disease Research Center and a professor of pathology, neurology, and neuroscience at the Hopkins Medical Institutions. He is part of a team of researchers from the center and from Harvard University who recently reported on their findings.

Hormonal changes

Old age also modifies the body's endocrine system, including glands that secrete hormones, the complex compounds that act directly on or stimulate other organs to regulate physiological changes. These changes were once thought to be linked to a decline in the number of hormone receptors on the cell surface, making aging cells less responsive to hormones. But research during the past decade has shown that a hormone can penetrate a cell's surface.

Here again, some symptoms may indicate disease while others are evidence of normal aging. Older men and women are more susceptible to diabetes mellitus, a metabolic disorder related to the use of insulin. However, old age frequently brings higher blood sugar levels—older bodies tend to lose the ability to use sugar efficiently. Diabetes, in fact, has been described as accelerated aging because some of its complications—cataracts, stiffness in joints, and atherosclerosis—are common in the elderly. Recently, the official guidelines for determining diabetes were revised. As a result, fewer elderly are being incorrectly diagnosed as diabetic and needlessly put on insulin.

In women, the normal cessation of menstruation is related to a drop in estrogen, sometimes resulting in osteoporosis and a tightening and drying of vaginal tissues. Men don't go through a normal, hormonal change comparable to menopause, but they are subject to an age-related enlargement of the prostate gland, an endocrine disorder often requiring surgery. However, healthy older men maintain the same levels of testosterone as do healthy young men, studies from the NIA's Gerontology Research Center have shown.

Eyes and ears

A gradual decline in hearing is an expected part of aging: About half of Americans over 65 will suffer from presbycusis, according to the NIA. Distance vision, too, commonly decreases with age, yet elderly people with no eye disease can maintain reasonably good visual acuity (20/40 or better) into their 80s, according to the BLSA.

One example of an age-related eye disease is senile macular degeneration, a disorder of the ocular blood vessels that primarily afflicts people over 50. Until recently, this was the culprit in about 16,000 new cases of blindness every year, or 17 percent of all new cases of blindness among Americans. Today an estimated 90 percent of such cases can be treated with an argon laser beam that seals leaky blood vessels in the eye through photocoagulation, pioneered at Hopkins.

The cellular level

Overall, the incidence of such chronic diseases as osteoporosis, arthritis, cardiovascular disease, and cancer goes up with age. Some 80 percent of Americans

The graying of the globe

By the year 2030, some 17 to 20 percent of the American population will be over 65, compared to 4 percent in 1900. Those over 85 are the fastest growing population segment.

Until recently, problems of the oldest group of the elderly were thought of primarily as the province of women. But in the past few years the sex gap in longevity has fallen from eight to about seven years, according to the U.S. Department of Health and Human Services. The narrowing of the gap is attributed in part to escalating rates for lung cancer in women.

While the United States is experiencing an unprecedented explosion in the over-65 group, other industrialized nations are also facing the enormous medical, social, and economic implications of a graying society.

But the challenge is truly a global one. Until recently, this longevity explosion was considered to be mainly a phenomenon of industrialized countries. However, around 1980 the number of older people in developing nations began to catch up, according to a study at Flinders University of South Australia. By the year 2000, there will be 229 million people over age 65 in developing nations compared to 167 million in the industrialized world. This large population of older people in the Third World will strain the scarce medical and economic resources of struggling nations and the countries that lend them money.

By the year 2025, the world will have 1.1 billion people aged 60 or over. In China, the population in that age bracket alone will exceed the entire population of the United States. —Peggy Eastman

BILL EVITTS, AGE 44

"The more you know, the better you get."

"Everything's got its moments," Bill Evitts says, "though I wouldn't consider much before college. High school is a vastly overrated phenomenon."

Evitts enjoyed every stage of his academic career, from college through graduate school and teaching college-level Southern history: "I liked it as much the day I walked away as the day I started."

But he had reached the point "where you either speed up and become a senior person, or you hit some kind of burnout and make some changes. I got lucky; something fell on me. I turned in a tenured professorship and, on very short notice, moved my family back to Baltimore."

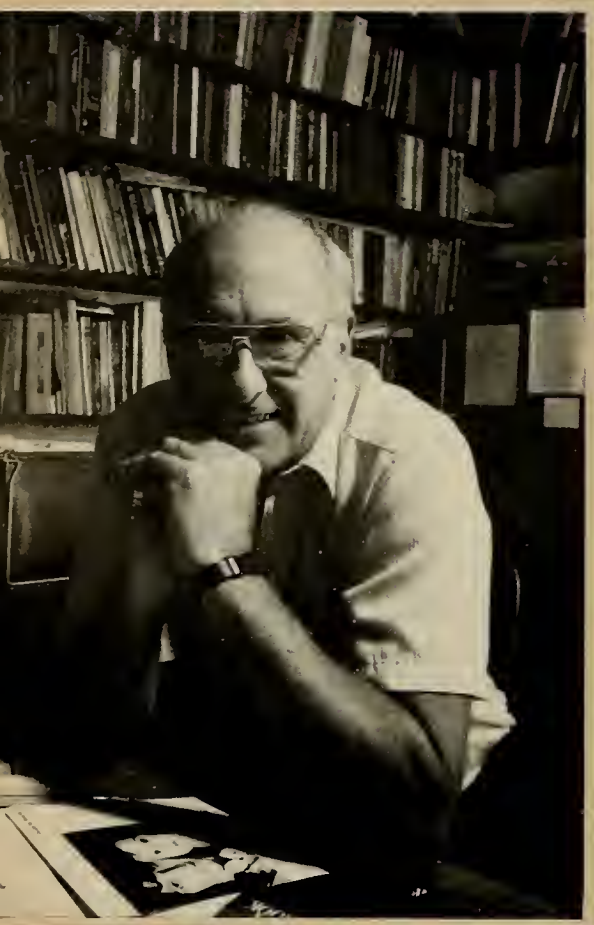
As Johns Hopkins University's director of alumni relations, he sees a steady procession of stages in his life. He speaks fondly of the charms of college, a first job, a new family. Though the procession seems orderly, he warns, "Time seems to compress as you get older. This has been accelerated for me by the fact that my son is starting at Hopkins in the fall, and he's going through some experiences that I can vividly remember myself, except that now it's my own son.

"It's sometimes less difficult to cope with the reality of being, say, 45 rather than 35, than it is to cope with your perceptions of yourself. You keep thinking of yourself as 26 or 18, and sometimes you get into trouble by trying to do things physically that you really should back off on, or being shattered by the realization that you don't look like you used to."

At the same time, he does not necessarily find a sense of perspective comforting. "It is a little scary to be able to look that far back and that far forward. I suspect that people in their 40s are more wired up and uptight about this than people in their 60s. Life's like the humanities: the more you know, the better you get. If you don't let yourself harden, you're going to in many senses get better and better and better."

DONALD TYRRELL, AGE 52

"Many of the people we canoe with are not much older than our kids."



Donald J. Tyrrell took up whitewater canoeing because "my wife made me sell my motorcycle, and I had some spare money, so I bought a canoe.

"The last hobby she and I both had was modern dancing, and before that it was jogging, and before that it was working, and youth." Long before that, it was kindergarten, where they met.

During the week, Tyrrell studies infant development in the psychology labs of Franklin and Marshall College. Every weekend that he and his wife can get away, they're on the Cheat, the Ocoee, the Nantahala, or one of a dozen other rivers within a day's drive from Lancaster, Pa.

"Many of the people whom we canoe with regularly are not that much older than our kids," Tyrrell says. He gets stares, offers of help, and eventually respect from them, and tries to make converts among their parents. "They say, 'Nah, I'm too old for that stuff'— but then they meet us and we're as old, if not older than, they are."

Tyrrell tries to fit in as much of his favorite sport as he can, recognizing that, at the age of 52, he may not be far from the time when he will no longer want to spend his weekends shooting over sharp rocks in a wet boat. But then, he estimates, he has about 20 years to go in his research on infant development.

"The hot, new stuff that I learned in graduate school is now no longer even covered in the intro psychology textbook," he says. "I am not as expert on the hot, new things as the kids coming out of graduate school are. But they don't have the context in which to embed that, they don't have the historical development, they don't know what's been tried and has not worked. The young kids think the new information is all there is."

over 65 years old have a chronic disability. About 27 percent have heart disease and 44 percent experience arthritis. This rising tide of disability may be at least partly due to an age-related decline in ability of some cells to reproduce, an impairment that also interferes with the healing of wounds and the functioning of the immune system.

Support for a "cellular rundown" theory of aging, based on the idea that cells have a limited lifespan and functional capacity, comes from the work of microbiologist Leonard Hayflick, now at the University of Florida. His earlier work at the Wistar Institute led to a widely accepted model, known as the Hayflick limit, to describe this finite number of doublings for normal cells cultured in a laboratory. Even if our age's major diseases were eliminated, a human would still have a life span of no more than about 115 years because of this cellular limit, he has written. Not only do normal cultured cells have a finite number of doublings, but they even "remember"— perhaps with a kind of molecular chronometer—that level, even when frozen for years. When thawed, they pick up where they left off in replicating until they reach this limit. Hayflick has found that occurring in human cells frozen for as long as 25 years.

Normal human cells cultured in a laboratory double about 50 times and then die, explains Rene Herrera, the WPI professor of biotechnology. Cells from an elderly person—approaching this Hayflick limit—undergo far fewer doublings than do those from a baby. There's an inverse relationship, in fact, between the age of the donor and the doubling potential of human lung and skin fibroblasts and certain other cells.

Cells as they age tend to accumulate excess or inaccurate genetic material. In seeking to code the genetic program for aging, Herrera studies the expression of certain types of ribonucleic acid (RNA) called small nuclear RNAs or snRNAs, which are known to edit this material. These molecules, which rid the gene of information not used in protein production and splice together the remaining message, play an important part in the normal functioning of the cell. Perhaps, Herrera theorizes, aging may be related to a loss, increase, or malfunction of these 10 or 20 types of snRNAs. Gene products must be spliced to produce proteins, essential for regulating metabolism. So in making even very small mod-

JUDY STRAUSS SCHWARTZ, AGE 35

"I had the best time of my life turning 30."

One summer Judy Strauss Schwartz decided she wanted to get a job with a program for blind children.

"My mother said to me, 'I think before you do that you should get a volunteer job; you've never worked with the blind.' " So Schwartz made her case to a placement counselor at the Westchester Volunteer Bureau:

"I went through my whole list of why I wanted to work with blind children, and she said 'How old are you?' I said, '16.' " Unfortunately, volunteers had to be of college age. "I told her, 'You have to give me a chance.' I talked myself into it. She hired me, and I loved it. I worked with kids from ages 6 to 16—some were my age, but they thought I was one of the college students. The next year, I headed all their college volunteers."

After years of teaching blind students mobility—the art of being able to cross streets or take train trips unassisted—she became development and community relations coordinator for the New York Institute for Special Education. As head of Case Western Reserve University's New York alumni chapter, she organizes events like the annual get-together when the Cleveland Symphony comes to Carnegie Hall.

"The only birthday I remember being really terrible was 19. I didn't like being 19. But since then, life has been very good. I think the only thing that's gone by very fast is our marriage. It's hard to believe it's seven years.

"People always told me that turning 30 would be traumatic, but I had the best time of my life turning 30. I spent two weeks partying. Thirty-five sort of came and went. Ed gave me a bicycle, and bought himself one. People say, 'What will you feel like when you're 40?' and I say, 'I'll probably party like I did when I was 30.' "

JOHN SCALVI, AGE 71

"The old adage still holds—so little time, so much to do."

The wing of the Flying Tiger aircraft that hangs in the National Air and Space Museum, the steel structure of Washington's RFK stadium, and bridges and buildings across the country are the visible trail left by John Scalvi. Now 71, the civil engineer has alighted in the earthquakes and volcanoes division of the National Science Foundation. It was the latest in a series of career moves that seem less abrupt for being spread between the Depression, when Scalvi graduated from Worcester Polytechnic Institute, and the present.

"I came to government with the idea that I was getting into a new area, although at that time I was pretty well along in years. And you might ask, was I afraid? I didn't really give it a thought. I took the opportunity as it came.

"Fifteen years is long enough in a given area," he has decided. "When I look back now, my teaching career was about 15 years, my industry career was about 12, and now I'm in government, and I'm in my 16th year here."

It's understandably hard for Scalvi to pick a high point, but he says his favorite years may have been those he spent in the steel industry.

"The nice part was that my wife was able to accompany me and we had the opportunity to visit almost every state in the country. Plus, we were at the peak of our health. The kids were off, and then they were married, so we didn't have to worry. I'm only 12 hours older than my wife. We were born in two small towns in Massachusetts. I was born before midnight, she was born after midnight."

He spends a lot of time now trying to convince faculty and students who specialize in narrow fields and who are infatuated with computers that great opportunities exist in civil engineering.

"Oddly enough, I have to suggest new things to some of these young people. They want to do what they've been doing, and they don't see the broad picture or the need.

"I hate to use the word challenging, because everyone says 'challenging,' but it's something that has to be done," Scalvi says of his mission. "The nation needs it, and people should be getting into it. So it's as though I just graduated with a B.S. degree.

"The old adage still holds—so much to be done, so little time."

ifications in cellular functioning and reproduction, these molecules could have a rather large impact on metabolism. While that would seem to point to a genetic cause of aging, he cautions, "It's impossible to tackle the question of whether it's environmental or genetic."

Of course it is not yet possible to alter the genetic code to extend life. But even common sense tells us that toxic wastes, spoiled food, and cigarette smoke could have similar effects. For someone whose genes are particularly susceptible, such environmental factors can hasten certain diseases linked to aging.

New evidence for an environmental and genetic linkage comes from the field of rheumatology, the study of arthritic diseases. Following a 1985 spring outbreak of food poisoning in Chicago caused by *Salmonella* bacteria borne in

milk, researchers at the University of Michigan identified a type of arthritis they call reactive arthritis syndrome. About 5 percent of the approximately six million people each year who get *Salmonella* food poisoning will later develop arthritis—often within the year, says Michigan's Robert W. Ike. Other studies on reactive arthritis have shown that those 5 percent all seem to have the same tissue type (called HLA-B27 to describe its genetic arrangement of proteins). "Our hypothesis is that B27 proteins may interact with a similar protein in bacteria to cause reactive arthritis syndrome," explains David T.Y. Yu, an associate professor at the University of California at Los Angeles.

Stay active and alert

If aging is due to a cellular limit, then wouldn't a decrease in activity help to save wear-and-tear and give cells their best chance to multiply and thrive? Not so, according to many studies on physical activity and aging. Doctors know, from studies of bed-bound invalids and astronauts in weightless conditions, that forced inactivity is the fastest route to premature aging. The advice to "use it or lose it" seems to be valuable for just about every part of the body and mind.

Regular, vigorous exercise, along with boosting the efficiency of the heart and lungs, can increase high-density lipoprotein cholesterol, known as the "good" cholesterol because it offers some protection against heart attacks. Exercise can also lower the concentration of triglycerides, the fatty substances that are the culprits in atherosclerosis, note Andrew P. Goldberg and co-workers at

Myths and facts about life-lengthening fads

Potions and incantations, rituals and exotic remedies, used to be mainstays of trying to stave off old age. Legends and literature told of fabled fountains of youth and lands promising a detour around death and debilitation. While an elixir still eludes us, science has taken up where the alchemists left off.

In many an age past, the gullible could take their choice from an enticing array of quackery and quirky promises. For instance James Graham earned a fortune in London in the 1780s by purveying a dozen quite costly medicines at his Temple of Health.

His "Aetherial Ambrosial Quintessence" was guaranteed to have been manufactured in the "Adepti-Alchyrical Medico-Electrical and Philosophic Apparatus." This marvelous metallic, glass, and magnetic contraption, pronounced Graham, was "infinitely superior to anything that now is or ever was in the world."

At his temple, those so inclined could sleep on the "Grand Celestial or Magnetic-Electrico Bed." Forty pillars of glass supported the 12-by-9-foot frame and its dome, fragrant with spices and essences. Groups of figures on the dome held aloft flutes, kettledrums, oboes, and other instruments that "by the most expensive mechanism, breath(ed) forth sound," the advertisement assured the public. Such a rejuvenation cost the astronomical sum of 50 British pounds a night. "It may even have been worth it," muses David P. Barash in *Aging: An Exploration*, his engaging book melding mythology and biology.

In our own age, the yearning for a magic potion to slow down aging remains strong, though the strategies and substances have changed dramatically. The trouble is, no one has yet found a way to circumvent the fate nature intends. But research is uncovering some fascinating avenues along with the dead end streets.

• *Dietary antioxidants.* Proponents of the "free-radical" theory of aging suggest that by-products of chemical reactions damage cells beyond repair during normal metabolism. To block "free radicals," those short-lived oxygen molecules, they are looking into certain antioxidant substances—among them vitamins A, C, and E and the mineral selenium.

To date, there's no agreement on how much of a role free radicals play in aging, though it's a promising area in research. Nor is there agreement on whether an antioxidant regimen can extend life, or, if it can, what the daily dosage should be. In fact, large quantities of vitamin A and selenium can be highly toxic.

• *Superoxide dismutase (SOD).* SOD, present in most cells, is the scavenger that mops up the free radicals. This naturally occurring enzyme, which seems to protect cells from damage, is more active in long-lived species than in those with shorter life spans. Could SOD extend life? Proof has yet to emerge. SOD supplements, sold over-the-counter, are of little use since the protein in SOD breaks down during digestion and the cells can't reassemble it.

However, scavenger drugs that block free radicals are being tested for use in human organ transplants, where the rush of blood back into an organ after surgery overwhelms the cell's scavenger system.

• *Calorie-restricted diets.* In the 1930s, Clive M. McCay reported that undernutrition (30 to 50 percent fewer calories than normal) could extend the life span of rats, leading to speculation that it might do the same in humans. The rats, fed such a diet since infancy, showed stunted growth but stronger immune systems. Naturally, there's been no interest in producing a nation of hungry, growth-retarded children in the uncertain hope that they might live longer.

• *Gerovital-H_3.* This is a salt solution of the pain killer procaine (Novocain) and stabilizing agents. Ana Aslan of Romania has heavily promoted Gerovital-H_3 to slow down the bodily changes accompanying aging. She runs a state-supported rejuvenation clinic visited by Charles de Gaulle and Marlene Dietrich, among other hopefuls. But the procaine hydrochloride is primarily an anti-depressant and an anesthetic. If you're glum, it may make you cheerier. But younger?

• *Dehydroepiandrosterone (DHEA).* Produced in the adrenal gland, this hormone is found in higher concentrations in the blood of younger people than of elderly ones. DHEA is hardly detectable in those age 70. In studies, rats given DHEA supplements tend to live longer, but there is no convincing evidence to suggest that taking DHEA supplements can extend human life.

—Peggy Eastman and
Donna Shoemaker

the Francis Scott Key Medical Center at Hopkins. They have shown that the normal age-related decline in maximum aerobic performance can vary. Armchair sitters may lose up to 10 percent per decade, while highly trained master athletes might show only a 5 percent loss over the same period. Exercise also stimulates glucose receptors in the muscles, thereby cutting down on the amount of sugar in the blood stream and on the chance of developing diabetes.

But exercise has to be continued over a lifetime to keep its protective edge. Middle-aged and older athletes who continue to train as competitive runners have an oxygen intake capacity 50 percent or more higher than that of ex-athletes of the same age who have stopped training, says Claude J.M. L'Enfant, director of the National Heart, Lung, and Blood Institute.

Calcium and estrogen are frequently prescribed to strengthen bone mass in women. But might exercise also protect against osteoporosis by stimulating bone tissue turnover and building up bone density? To study that question, Christopher Ruff, a Hopkins anatomist at Key, is comparing the bones of aging female beagles who run five hours a week on a treadmill with a control group of age-matched sedentary beagles. In human years, the dogs are between 65 and 80. The bones of beagles are almost identical to human bones in histological structure and mechanical properties, says Ruff, assistant professor of cell biology and anatomy and an orthopedic surgeon. In earlier studies (using younger animals), exercise led to a 20 to 30 percent increase in localized bone mass.

In this second phase of the study, every five months the researchers take computer-assisted measurements on the loads and stresses on the beagle bones to determine changes in shape and density. The study is also testing other potential causes of osteoporosis, including lower levels of estrogen, calcium, and parathyroid hormone.The results might help to provide the answer to whether regular, load-bearing exercise strengthens the structure of bones and aids in preventing hip fractures.

Weighing in for life

Proper diet, along with exercise, can slow some age-related changes in the body. Eating too much of the wrong foods—a common American habit—puts fat on the frame and fat in the blood stream. But the concept of ideal weight has been shaken of late. No one can say for sure what obesity is, although the American Heart Association and the National Cancer Institute do agree that the obese are at risk for heart disease and cancer.

The controversy heated up when Reubin Andres, a Hopkins professor of medicine, analyzed data on the relationship between body weight and life span. In general, he found that healthy people who weigh 10 to 15 percent more than the previously set "ideal weight" (as defined by the widely used 1959 Metropolitan Life Insurance Company charts) tend to outlive other underweight or average adults. In 1983, Metropolitan Life revised its "ideal weight" charts upward, a step criticized by some physicians who remain convinced that thinner is healthier.

"The basic contention of my 'contentious concept' is that it seems to be appropriate to gain weight as you grow older," says Andres, who also is clinical director of the NIA Gerontology Research Center at Key. "The question is, is it more important what your cholesterol is or whether you live or die? Would you rather be alive with a high cholesterol or dead with a low cholesterol?"

Andres takes a philosophical view of

Tanning: Is it a fading trend?

What prompts the desire for a glorious tan? The social pressure to look young. What makes skin look old? Too much exposure to the sun. Hmmm. There's a Catch-22 to catching some rays.

For an office-bound worker, a tan conjures up looking healthy, feeling relaxed, and managing well enough to have jetted off to Jamaica. Another often cited justification for tanning is to pump up production of vitamin D, though low levels of sunshine will do that nicely.

Even in summer, fans flock to tanning booths. Why? "Before they go on vacation, they like to build up a tan in a controlled fashion," suggests Paul Strickland. But the Johns Hopkins School of Public Health assistant professor and environmental health researcher would prefer that tanners seek some cover instead.

Tanning is the skin's attempt to shield itself from ultraviolet radiation (UV); sun screens serve the same function. Tanning results when the epidermis steps up production of melanin, the brown or black pigment designed to absorb harmful rays. But overexposure to UV rays can be carcinogenic. "The majority of nonmelanoma skin cancers are associated with sun exposure," Strickland says. And, he adds, epidemiological evidence seems to be mounting to indict the sun as an agent in melanoma as well.

He believes there's a new culprit indoors: the ultraviolet light bulbs used in tanning lamps, which produce UVA radiation. Thus he suggests more regulation of tanning studios, many of which, ironically, are located in health spas.

Five or 10 years ago, UVB bulbs were used in most tanning lamps, but have been replaced by UVAs, thought to be safer. "It takes a much higher exposure to UVA to induce suntan and tissue damage," Strickland says. But in his tests on albino mice (which are not susceptible to melanoma), UVA rays produced cancerous lesions.

UVA rays are the long-wave-length rays closest to the visible light spectrum; they range from 320 to 400 nanometers (nm). At the Earth's surface, 95 percent of UV rays are type A, while only 5 percent are mid-length B type, 280 to 320 nm. UVC rays, the third kind at 200 to 280 nm, are the shortest and most hazardous ultraviolet ray. But UVC rays don't pass through the protective ozone layer to reach the beach. "This is the reason why the ozone layer is so important—it's absorbing everything below 290 nm," he explains.

UV rays destroy certain proteins in the skin that give it elasticity. When the protein breaks down, the skin begins to look like leather. "The appearance of the skin is the major factor we use to visually assess the age of an adult. An individual who works outdoors in a hot, dry climate can look 20 years older," Strickland notes.

But the paler look may be having a revival. Says Strickland, "the impression I have is that the trend might be swinging back. A lot of people are beginning to realize the dangers."

—Donna Shoemaker

MILLARD MILBURN RICE, AGE 93

"I don't use a cane and I don't feel old."

Many people have asked Millard Milburn Rice how he has lived to be almost 93. Though he respectfully credits his ancestors, he puts more faith in a lesson he learned years ago.

"I spent 13 years in a little mining town 7,000 feet up in the Colorado Rockies, recovering from an ailment resulting from my service in World War I. He had been a student at Western Maryland College when the war broke out.

"I knew that my chance of recovery was about 50-50, and somehow I adopted a fatalistic attitude. I followed a careful regimen and resolved to keep my mind active and to push all worry as far into the background as possible."

He follows the same rules now that he is retired from a job as a bank vice-president and semi-retired from an avocation as a local historian. "To avoid boredom," he says, he fully indulgences passions for reading, baseball, and walking. "I don't use a cane, and I don't feel old."

Most of the changes in his lifestyle he cheerfully accepts. But the move to his single room in Frederick, Md., was trying even for one with a long education in patience.

"For 10 years following my wife's death I had continued to live in a spacious apartment surrounded by lawns and trees. In the retirement center I knew that I would live in a very small room overlooking roof tops. That knowledge alone generated a reluctance to move, and combined with the knowledge that I should be forever separated from most of my possessions, the decision became traumatic.

"The separation leaves a sense of loss almost impossible to express. I have been asked how to adjust."

On approaching death and dying

"One advantage of old age is the clarity of vision. Not everyone has it, and it would be wrong to romanticize old age. But those who do have a much sounder sense of values, which comes of looking death in the eye."

The thoughts are those of John Caputo, professor of philosophy at Villanova University. He likes the word mortal. "It's a good word; it describes our condition as humans. We are the only beings who die—other beings perish. We're the only ones who experience mortality, because we are projected ahead of ourselves. We have what Heidegger called 'being toward death.' We tend to say death is something off in the future that's not going to happen, not to me, not yet. So we turn ourselves over to present distractions." He adds that ours is "a culture of youth, a culture of erasing the time process. People in their 60s want to look like people in their 30s."

Through his interest in existentialism, he thinks of time in two guises, human temporality and objective time. The time of objects, he explains, "is homogeneous. What you have is only units of the present. The future is what didn't happen yet, the past is what is over."

But in human temporality, "the focus on the now is diminished. You're oriented toward the future. You're always moving ahead of yourself. You also have your past in the back of your head. The movement of the present seems to vanish. You become literally ecstatic, extended out of yourself."

Often, the young are the ones most entranced by "now" time, by immediate gratification, into idling the present away. What's it like to talk with a class of freshmen about death? Says Caputo, 46, "It's practically impossible. 'Death' tends to just bounce off an 18 year old. They are so vitally throbbing. But as you get older, you hear it."

What we hear is that death is coming, sooner or later. But, says Caputo, "the projection upon death is salutary, a constructive thing. If confronted squarely, it's not a morbidity or moroseness, but it's seeing yourself in a cold, white light. And that's liberating."

—Donna Shoemaker

the controversy on fatness and longevity. "In my talks and writings, I have compared obesity to a Jekyll and Hyde sort of variable. We need quite a bit of body fat, but what's it there for? We certainly don't need it to survive an overnight fast. And we certainly don't need it to survive weeks of fasting—at least not anymore. Any advantage that the plump cave man had certainly should not apply to modern people."

Part of the paradox of extra pounds—that they are associated with disease but may aid longevity—may be explained by the fact that there are different kinds of fat. In terms of the chronic diseases of aging, it's better to be shaped like a pear—known as female-pattern obesity—than like a pot—known as male-pattern obesity. The pot-bellied are worse off because "adipose tissue inside the abdomen drains directly into the liver," says Andres, "so the blood leaving that tissue is heavily laden with harmful fat. Whereas the fat around the hips and thighs doesn't go to the liver, it goes generally everywhere."

Diet and a long life

Although the medical profession may not agree on what ideal body weight is, it is reaching some common ground on what kind of diet helps people live longer.

New evidence that diet can help to reverse artherosclerosis comes from a study of men aged 40 to 59, conducted by the National Heart, Lung, and Blood Institute. A stringent low-fat diet, coupled with a cholesterol-lowering drug and niacin, actually helped to widen portions of narrowed blood vessels in men who had previously had coronary bypass surgery. Of those following the test regimen, 16 percent showed actual arterial widening, compared with only 2.4 percent in the control group on a more normal diet.

The American Heart Association's low-fat, low-cholesterol diet recommended to prevent heart disease and the National Cancer Institute's diet to prevent cancer are almost the same. Both say to avoid foods high in saturated fat (such as marbled steak and butter), cholesterol (such as organ meats), and sugar and salt. Not surprisingly, they recommend eating more fresh fruits, vegetables, and whole-grain cereal and breads.

Recently the heart association revised its dietary guidelines to focus more on the link between calorie intake and cholesterol. "Calories do make a difference—that's one of the major messages," says W. Virgil Brown, professor of medicine at Mt. Sinai School of Medicine in New York.

Along with its recommendation that fat should make up less than 30 percent of what we eat, the heart association now advises that cholesterol should be no more than 100 mg per 1,000 calories consumed, not to exceed 300 mg a day. Sample menus show how substitution can reduce calories and thus cholesterol, for example, munching an apple instead of six chocolate sandwich cookies or substituting an eight-ounce glass of skim milk for a deviled egg and cheese sauce.

Skim milk also rates high with doctors treating older women because it's low in fat but high in calcium (an eight-ounce glass contains about 300 mg). While calcium can't compensate for the drop in estrogen accompanying menopause, the often-prescribed daily dose of estrogen could be reduced if women would take in 1,500 mg of calcium every day, concluded panelists at a recent NIH workshop on osteoporosis.

The attitude factor

Research into the intricate connections between the brain, the central nervous system, and the immune system—a field called psychoneuroimmunology—is confirming that how we think may affect our susceptibility to disease.

In the absence of illness, personality remains fairly constant over a lifetime, the BLSA reveals. Thus the stereotype of an older person becoming cranky and difficult is false. It's unlikely, unless he or she was cranky in youth and middle age.

In studies of how older people perceive their health and well-being, those who say they feel pretty good are, in fact, relatively healthy. Do they feel good simply because they think they do, perhaps ignoring aches and pains that may be present? That's hard to sort out, but it is clear that attitude exerts a strong influence on healthful aging.

While aging is inevitable and the cellular clock continues to tick even as you read this, practicing a healthy lifestyle throughout your life does give you an edge on old age. No one can change inherited genes, but changing habits is within anyone's grasp.

Peggy Eastman is a free-lance writer specializing in gerontology and living in Chevy Chase, Md.

London Bridges Building Up

With pageantry and grace, Great Britain welcomed 12 undergraduates whose seven weeks of hard work christened WPI's new London Project Center.

By Kenneth McDonnell

It's over now. The reports have been written and polished. The final presentations have been given and good-byes exchanged, along with mementos of thanks and new-found friendships.

The student teams have disbanded and gone their separate ways—most of their members off to the playground that is Europe in the summer, others back to the States for summer jobs. They will regroup in September, no doubt, for debriefing and reminiscing, and then on to their junior or senior years—one more episode in their education.

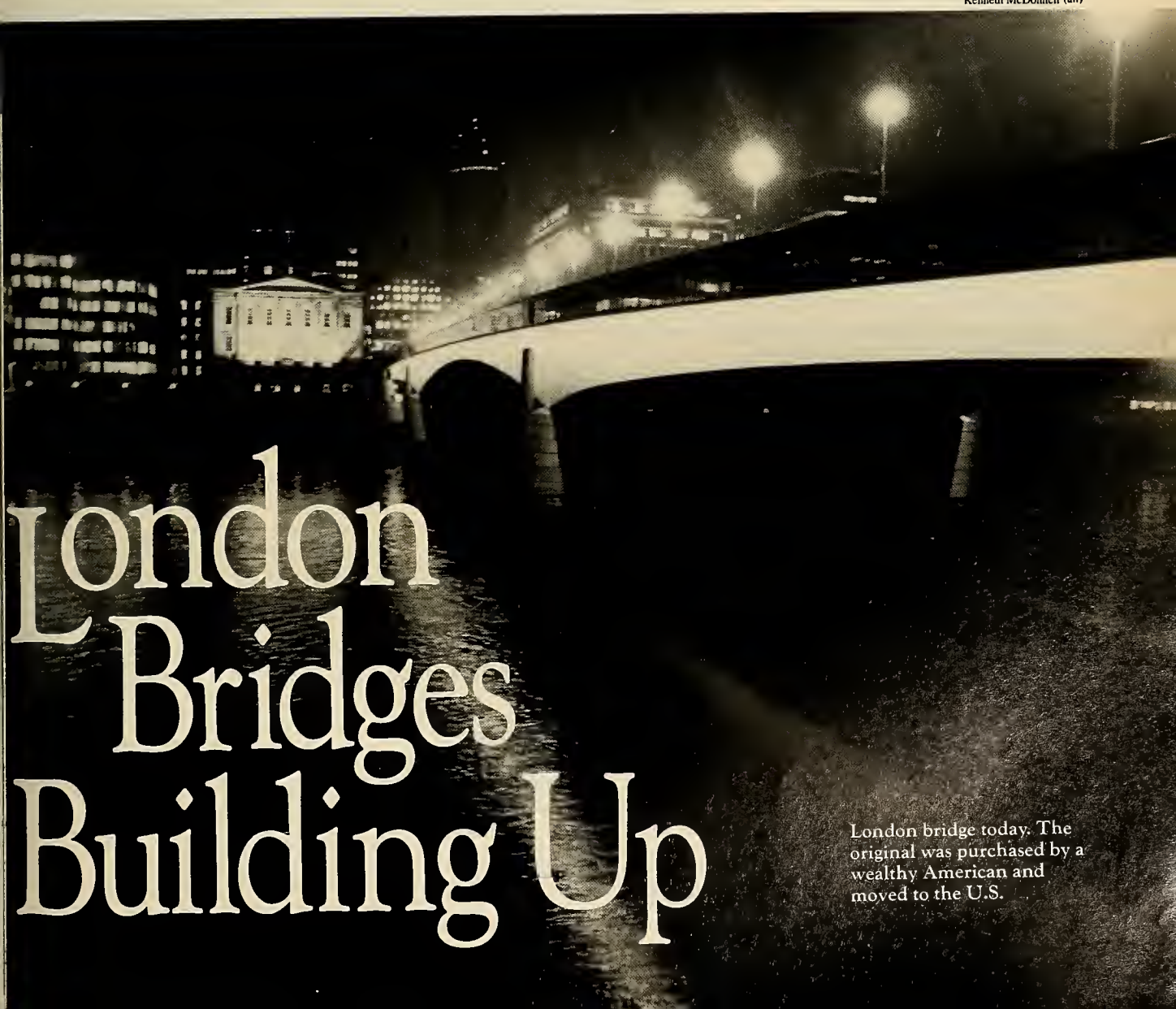
In completing their Interactive Qualifying Projects (IQPs), these 12 undergraduates, the first to represent the college at its new London Project Center (LPC), have established WPI as a significant presence in Great Britain—a presence that is certain to increase in the years ahead.

"Frankly, I was surprised by how happy each of the four agencies was with what our students achieved," says humanities Professor John Zeugner, co-advisor at the LPC this year. "The kids had their hands full—seven weeks is little time to deal with a new culture and professional-level expectations—and I pushed them pretty hard throughout the term.

"Still, the amount of time the agency liaisons spent with each group and the close relevance of each project to the mission of the sponsoring group are marvelous indications that all the hard work will find receptive ears in this year's sponsor organizations—and has already opened more doors in Britain."

MODELED AFTER WPI's Washington, D.C., Project Center, established in 1974, the LPC is largely the culmination of the 14-year student exchange program

Kenneth McDonnell (all)



London bridge today. The original was purchased by a wealthy American and moved to the U.S.

"The kids had their hands full.
Seven weeks is little time to deal with a new culture and professional-level expectations."

between WPI and The City University of London. In Washington alone, some 500 students and 40 faculty members have completed more than 200 IQPs with 50 government agencies and private organizations.

Now, the LPC adds a cross-cultural element to WPI's residential projects program. And it is the cultural exchange—even in a nation as socially similar to the U.S. as Britain—that is one of the major benefits and challenges of participation in the LPC.

"I think our students were surprised by just how *different* things are in the U.K.," says Zeugner, whose desire to serve in London derives from his interest in both teaching through projects and investigating how other cultures handle higher education.

It's the little things that matter, he says, such as dealing with differences in technical terminology and regular working hours, together with new social norms—proper silence on the Underground, London's exceptional subway network, and etiquette in England's fabled pubs. All told, it creates not only a challenging working environment for students but also the need to demonstrate, often for the first time, a sense of collegiate and even national ambassadorship.

And in every project, the proposals so meticulously conceived and presented prior to the students' departure in March needed altering once they got to London, due to normal progress achieved by the agencies themselves and changing conditions of the problems being addressed.

"It's all very exciting," Zeugner says, "but being in a place where you absolutely must carry a 300-page book of maps to get anywhere—well, you have to budget a little extra time for these things."

In London, there are, for example, 65 streets whose names contain the word queen. And it's said that to win an operator's licence, London's cabbies must pass an exhaustive, three-day examination

During a review session with advisor John F. Zeugner, professor of history at WPI, U.K. Patent Office project members pose for a photograph. Left to right: Robert A. Petrin '88, Andrew J. Scholand '89, and Sergio E. Levi '88.

testing their ability to get you to anywhere in London via the fastest, most economical route—and always in a clean, comfortable fashion with a courteous "Thanks, mate" at your destination.

"*Very* civilized," Zeugner says.

Junior Paul R. Mancini, an LPC student, adds, "It's so different here. At home, we go to class, crank out homework, go to project meetings, take exams, start again. Here, we have a problem to solve in a limited time within set parameters. We've got to develop resource networks quickly, building something from nothing in a strange place."

Considering the demands on their time, is there much left over for exploring this enchanting, non-stop city? "Weekends," says the mechanical engineering major.

In London, Mancini and teammates Jodi-Ann Medeiros and William F. Noel, juniors as well, worked on a project for the Worshipful Company of Scientific Instrument Makers. The Company, Noel explains, is one of England's many modern-day guilds, or liveries. These organizations were established in the Middle Ages by craftspeople in particular trades to regulate the activities of the

"It's all very exciting," Zeugner says, "but being in a place where you absolutely must carry a 300-page book of maps to get anywhere—well, you have to budget a little extra time for these things."

industry—by governing apprenticeships, setting prices, and playing a vital role in the lives of their members. Today, these fraternal groups continue to promote the welfare of their industries, but normally through channels similar to those of manufacturing associations.

Each year, for example, the Company gives an achievement award for the best commercially innovative technological instrument. The award, Medeiros notes, has always been well received, but until now the Company lacked a formal structure for selecting award nominees and winners. Past winners have included the scanning electron microscope and the EMI whole body scanner.

By studying the selection systems of similar awards and sources of new product information, such as trade publications, university research, patent office documents, and word-of-mouth resources, the team was able to recommend not only a more formal award format, but also a leading nominee for the 1987 award.

In addition, the team's final recommendations included showcasing the current year's winner at the guildhall and at British libraries and museums, providing the winning organization with an award crest for display, and perhaps changing the name of the prize as well. Their efforts should go far in promoting the prestige of the award.

The building in which the Company resides houses several other liveries like the launderers' and the glaziers' guilds. Located on the river Thames and abutting London Bridge—making the hall itself part of the historic City of London—Glaziers Hall was the site of the LPC inaugural banquet on April 13.

For the 80 guests assembled, it was an evening to exchange best wishes for the work ahead, to express appreciation for the close relationships that had already sprung up between WPI and British project sponsors, and, of course, to toast the queen—and the president.

Not only were the 12 project students on hand for all the introductions, the feasting, the speechmaking, and the classical music, but so were WPI representatives who journeyed to London for the inaugural event and to make plans for subsequent LPC projects in the spring of 1988. Those in attendance included Dean William R. Grogan '46; Dean John P. van Alstyne; Dean Frank Lutz and his wife, Evelyn; Professor Lance Schachterle, co-director of the LPC and director of the Division of Interdisciplinary Affairs (DIA), which oversees all IQPs; and freshmen Nancy A. McLaughlin and Jeffrey A. Yoder, who delivered greetings from the Class of 1990.

Also in attendance were alumni George H. Long '57 and his wife, Linda; Henry M. Strage '54; and Robert Wolff '51 and his wife, Millicent.

The LPC had been in the planning

Juniors Henry J. Clark III, Michelle A. Pence, and David A. Burrage catalogued the papers and wrote a biographical sketch of the British inventor Albert H. Midgley for the Institution of Electrical Engineers.

In completing their IQPs, these 12 undergraduates have established WPI as a significant presence in Great Britain—a presence that is certain to increase in the years ahead.

At the conclusion of the inaugural banquet of the London Project Center, 10 of the dozen WPI students, together with the British advisor to one project, Peter M. Back, second from left, offer a most American rendition of the song whose chorus begins, "Do wah ditty ditty . . ."

stages for several years, thanks in part to the untiring efforts of Maria L. Watkins, co-director of the Center, co-advisor with Zeugner, and an adjunct associate professor in the DIA. A retired professor of electrical engineering at The City University and the first woman in England to teach EE, she has also established and managed nearly a dozen university exchange programs, including those of Clarkson and Syracuse universities.

She is also an active committee member of the Institution of Electrical Engineers, a member of the Worshipful Company of Scientific Instrument Makers, and one of just 50 female freemen, out of more than 1,000, of the City of London, which entitles her to vote for—or even become—the Lord Mayor of London.

And for WPI, she is a vital asset to the LPC, opening doors at high levels.

THE BANQUET seemed to lend a sense of British grace and style to the entire LPC venture with guildmasters in full regalia, the keynote address by Baroness Platt of Writtle, chairperson of the U.K. Equal Opportunities Commission, entitled "A Woman's Place Is in Industry," and the Thames just outside the window.

For the project students, the banquet was one of several testaments they would experience to the value of their work to their sponsor agencies. It was also, though, but an evening's respite from a commitment that demanded sometimes 60–70 hours of toil each week.

At the U.K. Patent Office (UKPO), for example, a typical week might find Sergio E. Levy '88, Robert A. Petrin '88, or Andrew J. Scholand '89 jetting off to The Hague to discuss elements of their project with representatives of the European Patent Office (EPO).

The project centered on the UKPO's concern over criticism of its patent searches uncovered in a survey conducted by an independent research group. The outside study examined the perceived satisfaction of the agency's users—patent agents, similar to U.S. patent attorneys—with UKPO searchers compared with those of the EPO.

Created in 1978 because of the desire of European national patent offices to ease the procedure for multinational patent protection, the EPO is today most attractive to that sector of industry interested in marketing its products throughout Europe. The UKPO, on the other hand, is used mainly by inventors whose chief concern is the British market.

In addition, the cost of an EPO search is often prohibitively high for single-market-oriented producers. But according to UKPO project liaison Peter M. Back, his agency and the EPO are not in direct competition, since they serve the needs of two different sectors of the economy.

"Patents are a tremendous source of technical information," says Scholand. "But patents have a tradeoff: The government gives you a limited monopoly on your invention in return for your revealing the smallest details of your innovation and thus allowing other people access to your ideas." And since patents—published documents—are often released long before an idea reaches the pages of technical journals, patents usually serve to publicize the lat-

est developments in any field.

Adds Petrin, "Patent offices actually have a vital societal responsibility to spur technology, since industry needs the strategic tools which new ideas provide."

As result of their work, the team found that in the previous independent study of UKPO and EPO searchers, the patent agents interviewed either misunderstood the differences between the two agencies, or were subject to a poorly constructed and analyzed questionnaire. Further, the students found that the price-quality balance of UKPO searches is reasonable, but that certain parts of the search report could stand to be improved.

According to Levy, all engineers and scientists should be interested in the arcane world of patents: "Just as technologists should be interested in improving society, they should also be aware of the fact that intellectual property can be defended."

Petrin says he hopes the results of the team's work will enable the UKPO to better market itself, an especially important task now that the number of patent applications is falling in the U.K. from as many as 20,000 per year.

ONE BRITISH INVENTOR who owned his share of patents was Albert H. Midgley (1881–1961). The son of an engineer, Midgley grew up at the time when electricity was gaining broad acceptance but was still in need of technological and safety developments.

It was the Victorian Age. England was well into the Industrial Revolution. Society demanded attention to high personal and professional standards, yet was reluctant to adopt new ideas and products. It was also a period of dramatic growth in the commercial and cultural development of London. Young, energetic technologists were flocking to the city to make their entrepreneurial marks. Albert Midgley was among them, coming south from his native Yorkshire to play his hand in the development of such innovations as electric streetcars, motor cars, lighting, radio, and cinema.

He did leave his mark, not only as an inventor, but also as an entrepreneur and businessman who improved on the ideas of others. Dynamos, electronic organs, radios, bomb fuses, and automatic timers and switches would bear his trademark throughout the first third of this century.

Midgley's papers, artifacts, drawings, journals, invoices, and patent specifications chronicle the remarkable changes in British technology during his life. But until three WPI students arrived in London, Midgley's things were stored, unsorted and uncataloged, in 81 boxes and tea chests at the British Institution of Electrical Engineers (IEE).

The tasks before juniors David A. Burrage, Henry J. Clark III, and Michelle Pence were to catalog the contents of the Midgley collection, at the same time suggesting which things might reasonably be discarded. In so doing, the team developed a computer program for fast, reliable indexing of the collection. Finally, the three wrote a biographical sketch of the inventor, based on sources in the collection, interviews with Midgley family members, and other

Among the distinguished guests at the banquet were (left to right) Dr. Elizabeth Laverick of the Institution of Electrical Engineers; R.J.F. Howard, master, Worshipful Company of Scientific Instrument Makers (WCSIM); Baroness Platt of Writtle, chairperson of the U.K. Equal Opportunities Commission; Professor Maria Watkins, co-director of the LPC; and G.G. Zahler, deputy master, WCSIM.

The banquet seemed to lend a sense of British grace and style to the entire LPC venture.

research, which placed him in the context of his time.

"We've tried to give researchers, historians, and inventors a resource to help them access information on one of Britain's most prodigious inventors," says Pence, "and at the same time create a cataloging system that can be useful for similar IEE archival collections."

In the process, adds Clark, "we've come to understand a lot more about British culture in Midgley's time and the dynamics of how new technologies are both developed and put on the market."

The inaugural banquet, held in Glaziers Hall, featured a keynote address by Baroness Platt of Writtle, chairperson of the U.K. Equal Opportunities Commission.

"IT'S OUR SECOND DAY in London. We walk into an IEE conference room for our first project meeting with our project advisors, expecting a 'Hi, how was your flight? How are you finding London?' But instead, we find ourselves face to face with a committee of eight serious people, obviously awaiting our arrival with high expectations of our future performance."

This, says John T. Powers '88, set the stage for what would become seven weeks of intensive efforts to both address the complex issue of his team's project and fulfill the expectations of IEE.

The students' mission, to project the manpower needs of electrical engineers in the U.K. to the year 2000, was based on fears that, by the turn of the century, the U.K. will be experiencing serious shortages in many engineering disciplines. To avoid this situation, says team member Karen A. Desrosiers '88, it is imperative that both British industry and education—from secondary schools through universities—take remedial steps now. "But considering economic supply and demand projections, the government may well need to do more to encourage careers in science and technology."

One way to do this, the team recommended, is to provide British students with more information on the bright future and excellent job opportunities in electrical engineering. Another is to increase the number of college courses offered at night, which would enable practicing engineers to gain further education and credentials in their chosen fields.

"The nation will clearly need more engineers in the decades ahead," says Mark Wartski '88, "but this means greater resources and publicity from grammar school on up. Without this kind of collaborative commitment by industry and government, and with the number of 18- and 19-year-olds still declining in the U.K., as in the U.S., the imbalance could worsen considerably."

To complete their project, the team relied on the data contained in IEE salary surveys of practicing engineers, together with extensive research of British industrial and educational programs. Salary surveys, says Wartski, yield significant indications of where the best opportunities lie in competing fields.

"To stimulate a nation's economy," he says, "there need to be adequate supplies of professionals in the appropriate fields. And in an increasingly technological—and competitive—world economy, in engineers and scientists lies much of the hope of a nation."

Already, five IQPs are planned with 15 students in London in the spring of 1988. According to Lance Schachterle, the Patent Office and the IEE have both indicated strong interest in continuing to

"We've got to develop resource networks quickly," says Junior Paul R. Mancini, "building something from nothing in a strange place."

offer project topics regularly, and plans are well along for a series of projects at the IEE on British women engineers.

New project contacts are being developed with the London office of Digital Equipment Corporation, with the British electronics firm Ferranti, and with the London Dry Docks Corporation, which oversees the major urban redevelopment project for the growth of London's financial district.

Schachterle and co-director Maria Watkins are also discussing a project on the patent activity of Dennis Gabor, perhaps best known for his fundamental work in holography. The Gabor project will be especially interesting in that the London liaison will be Prof. T. E. Allibone, a colleague of Gabor's and a member of the prestigious Royal Society, where the students will be doing much of their work.

"The success of the 1987 projects was crucial to getting such good contacts for 1988," says Schachterle. "Professor Zeugner not only worked the students hard, but also pushed himself to the limit to assist them." Working under the constraints of a new and unfamiliar environment, he adds, both students and faculty produced outstanding reports that prove again the basic philosophy of the WPI project program: If you treat students like young professionals and give them appropriate resources and responsibilities, you'll be astonished with the high quality of the results.

"What we need to do now," Watkins adds, "is to learn from our returning students how to arrange the living and social patterns to best support their tight work schedule. Being scattered around the northern suburbs is not an optimal living arrangement, and we all look forward to a day when WPI can establish a formal residential center in London for students and faculty to share."

During their visit to London in April, deans Lutz and Grogan also advanced plans for new cooperative programs with King's College and Imperial College, the two leading engineering programs in London. Along with the LPC, these new contacts will complement programs already in progress at the National Institute for Higher Education in Limerick, Ireland; University of Stirling, Scotland; and with several technological institutions in Switzerland, Sweden, and Germany.

Plans call for Professor John van Alstyne to serve as co-adviser to the LPC in 1988. A veteran of the Washington Project Center, where he'll advise projects again this fall, of his spring '88 plans he says, "After seeing how successful the LPC has been in just its first year, I'll have my hands full just keeping up with what our sponsoring agencies are coming to expect from WPI. But considering the caliber of students selected to represent the college, I guess I shouldn't be all that worried."

"Besides," he adds, "I can't wait to get back to London."

William F. Noel, Jodi-Ann Medeiros, and Paul R. Mancini, all juniors, take a break from a busy day in their offices that overlook the river Thames.

Better Access to Expanding Knowledge

INFO-TECH

One thing is certain about working in Gordon Library—you never know what people are going to ask next. And if you think the hardest research questions involve knotty engineering problems or esoteric scientific concepts, guess again.

Take, for instance, the Case of the Notre Dame Fight Song. "One morning I got a call from a woman who needed to find the words to the Notre Dame fight song, which she was supposed to sing for a gathering that night," recalls Carmen Brown, Gordon Library's head of public services.

A search through the Library's holdings and a call to a friend in WPI's financial aid office who had Notre Dame connections proved fruitless. But on her way to lunch that afternoon, Brown bumped into a faculty friend who was a Notre Dame alumnus. "I said, 'Quick, what are the words to the Notre Dame fight song?' The only way he could remember was to sing it, so we stood there on the quadrangle, singing at the top of our lungs, while I scribbled the words down on a copy of the *Boston Globe.*"

Later that day, when she reached the inquiring party, Brown once again sang a rousing rendition of the fight song as she dictated the words over the phone. "It turned out that the caller wasn't too sure of the tune, either," she laughs.

Certainly, it was not your run-of-the-mill research request. But Brown recounts the story as a good illustration of the way she and the other librarians are able to draw on all the resources WPI has to offer in order to find information. "The faculty and staff are really happy to help us," she says.

That story also tells a lot about the nature of library work. "The best thing about my job is the element of surprise,"

As computers help define the future of 20-year-old Gordon Library, Al Anderson and his staff rise to the challenge of satisfying more and more patrons hungry for knowledge.

By Evelyn Herwitz

says Special Collections Librarian Lora Brueck. As keeper of WPI's archives, Brueck likens her tasks to being on a treasure hunt: "You never know what's going to come in, or what's in a collection that hasn't been looked at for years. Sometimes you can uncover something quite valuable or original."

Responding to any and all information requests and sharing research discoveries with the WPI community are two of the George C. Gordon Library's most important tasks. Doing so in a way that makes the best use of available information technologies within an aesthetically pleasing and convenient setting has been the Library's goal since its creation 20 years ago.

While that mission has been largely realized, as it enters its third decade, Gordon Library is facing new challenges. Both the Library's holdings and WPI's student body have outgrown the Library's physical plant. As plans are made to accommodate that expansion, Library staff members are also wrestling with a broader issue: how to remain an adaptable, high-quality academic resource in an era when computer data bases are radically changing the way information is researched and stored.

Those concerns, if not anticipated, certainly were not a major worry when the Library was conceived in the mid-1960s. At the time, the main issues were much more basic: how to centralize the various departmental libraries around campus, to make books and other resources readily available across disciplines.

Planners were also thinking about some subtler, but equally significant, questions—questions about aesthetic design, adaptable space, and ways to unify the campus with a special building that all would enjoy using.

The impetus for the new library came from an accreditation review that criticized WPI's then-disparate department collections as insufficient for academic purposes. At the time, humanities and social science titles were located in the Library's precursor in Alden Hall, while the Electrical, Mechanical, Civil, and Physics departments all maintained their own collections, and the Chemistry and Chemical Engineering departments shared resources.

According to Albert G. Anderson, Jr., who joined WPI in 1963 to help plan the library of which he is now head librarian, the idea of a centralized facility did not go over big with some members of the faculty. "Many of them wanted to maintain their own collections," he says. "But President [Harry P.] Storke insisted."

Championed by Storke, the project took shape. The final plans called for a 65,000-square-foot, four-story building that could hold 200,000 books and seat 450 patrons, plus another 150 people in a special seminar room.

But it was also designed to be "more than just a typical library of the late '60s," says Anderson. "The architect wanted it to be aesthetically pleasing, a campus showcase. He wanted it to be what a building in WPI's future would look like, while staying within a reasonable budget."

Among the Library's foresightful innovations were wall-to-wall carpeting and the campus' first central air-conditioning system. Other features included a music room for listening to records and tapes,

Robert S. Arnold

Michael Carroll

Gordon Library, now 20 years old, remains unchanged outside, but much is new within. Below: Head Librarian Albert G. Anderson, Jr., strives to answer the need of a growing academic community for more and more technical services.

Below: Special Collections Librarian Lora T. Brueck with some of the treasures of the Gordon Archives, including (far left) a bronze head of the WPI mascot.

space on the top floor for art displays, meeting and seminar rooms, and storage for the Institute's archives.

The building's $2.5-million price tag was met in large part by a $5-million bequest from Cleveland industrialist George C. Gordon, of the Class of 1895, whose name is chiseled over the Library's entrance. Federal aid totaling $750,000 also paid for construction expenses.

Much has changed since Gordon Library opened its doors in 1967. To begin with, WPI's very makeup has radically altered, both in size and composition. In the past 20 years, enrollment has more than doubled, from 1,700 to 3,800.

How those students are learning has changed as well. Though classroom and individual study are still essential to the curriculum, with the introduction of the WPI Plan in the early 1970s undergraduates began spending much of their time working in groups for project courses.

For the Library, that growth of and shift to group study have put a premium on space. Particularly for project coursework, notes Carmen Brown, the few available study rooms are staked out early in the day, marked with "in use" signs to define turf, and not vacated until late at night. Those who can't find a room of their own often meet in the Music Room, which has evolved into an ad hoc project meeting place because it is also an enclosed, more private space.

To meet the growing demand for information, the Library has increased its book collection over fivefold, from 40,000 volumes when it opened to 200,500 today. But all those books, as well as 750,000 pieces of microform (microfilm and microfiche), 1,350 magazine titles, and 1,650 videotapes of various course lectures, take up a lot of room.

Michael Carroll

Buried Treasure

Theo Brown's extraordinary diaries have a special place in the WPI archives

SOME ODD AND INTRIGUING ITEMS have found their way into WPI's archives. There's the collection of tinware that WPI founder John Boynton made in his tin shop, a few of rocketry pioneer Robert Goddard's ('08) lab notebooks, and the bronze goat's head that replaced the stuffed remains of the Class of 1893's unfortunate mascot. (Legend has it that the Class of '93 couldn't decide what to do with their favorite goat over the summer, so they decided to do away with it but preserve its head. The stuffed goat—which inspired the naming of the former Goat's Head Pub, now Gompei's Place—lasted until the 1920s, when the Tech men decided a bronze version would be a more fitting mascot than the venerable but, by that time, tattered original.)

Then there are the diaries of Theophilus Brown. A member of the Class of 1901, Brown was a mechanical engineer and inventor of agricultural equipment who religiously recorded the details of his life in daily journal entries. Beginning with a brief entry in an 1893 pocket diary about electric cars running again on schedule, and ending with a poem on aging in the back of a novel-size 1970 blank book, the leather-bound journals fill a narrow bookcase in Gordon Library's archives.

What makes the diaries so fascinating is not only Brown's description of his life and ideas—many of which became patented inventions incorpo-

rated into tractor designs by John Deere Co.—but his illustrations as well. A talented artist with an eye for detail, Brown first drew many of his ideas in his journals, carefully illustrating each thought with pen and colored pencils.

During his 92 years (1879–1971), Brown came up with 158 patented inventions, most while working for Deere from 1911 until 1952. From time to time he enumerated those patents in his diaries; in one 1942 entry, he listed 24, including a mechanical power lift, a double power lift, and a self-contained power lift. Elsewhere that year he also mentioned patent applications for a plow that would maintain "constant depth of operation" and a mechanized manure spreader.

But such entries make up only a part of Brown's diaries. A family man, he included snapshots of his wife, children, and grandchildren, as well as sketches of his granddaughter, "Pooh," and Christmas cards he designed. And with as much care as he detailed his inventions, Brown also copied into his diaries letters from his son, Bill, and other family members.

Those letters provide the meat between often brief accounts of daily activities. And during World War II, they provide a window on daily life during a period of national crisis. "We are all projecting ourselves into the future these days, for in the next week or two our immediate fates will be fixed," wrote son Bill in November of 1942 from Officer Candidate School. "White slips of paper will soon be given to us to report to day or night 'boards'—night boards being fatal 99% of the time."

Underscoring the tension of the times, Brown illustrated the pages of his wartime diaries with carefully replicated newspaper headlines and hand-colored maps showing progress on the

Robert S. Arnold

various battle fronts. On October 27, 1942, beneath a headline copied from the Chicago *Tribune*, "BIG JAP DRIVE IN SOLOMONS! New U.S. Naval Losses: Sinking of Carrier Wasp Bared," Brown wrote:

"Quarterly Directors' [of Deere Co.] Meeting today. Implements are rationed and sales have taken a nose dive. Our volume for the year will be close to 95 million however. We have 60 millions in cash. The allotment for next year has just come out and will be for the Industry about 20% of 1941 production, but since manufacturers are graded into A, B & C classes, and the A class (which does more than 10 millions a year) is curtailed much more, it looks as tho' 10% of 1940 would be as much as we can expect to do. We are getting into war work in a big way so most of our employees will be busy."

And so was Brown. Despite the war, he kept on inventing. By the end of his life, Brown had received numerous awards for his work, including the first Cyrus H. McCormick Medal for outstanding service in agricultural engineering, WPI's Robert H. Goddard Award for Outstanding Professional Achievement, and the Distinguished Service Award from the National Safety Council for his work in farm safety.

That list could just as easily have included recognition of Brown as an historian and an artist. But such discoveries are perhaps best left to the curious reader who visits the Gordon Library's archives and learns firsthand from Theo Brown.

Below: Gordon's carrels are largely vacant in the early summer, but the library staff stays busy: (left to right) Helen M. Shuster, head of technical services; Cornelia B. Pomeroy, circulation librarian; Diana J. Johnson, reference/interlibrary loan librarian; and Carmen M. Brown, associate librarian and head of public services.

The storage problem was eased somewhat two years ago when space in Founders Hall was set aside to handle some of the Library's overflow. But constraints on storage and study space have prompted the Library staff and WPI administration to begin planning for some form of expansion in the near future. As part of that process, last February the Library surveyed students' opinions of its space and services; not surprisingly, the need for more group study rooms topped the list of findings. This fall, a survey of faculty priorities for the Library is planned.

One plan on the not-too-distant horizon calls for the College Computer Center, which houses academic and administrative computing resources, to be moved to Fuller Laboratories, WPI's planned information sciences building. Construction of Fuller will begin soon on land adjacent to the Library, Atwater Kent and Kaven Hall. This change will free some 9,000 square feet for Library use.

Michael Carroll

"We've got two to three years before we get into serious problems," Al Anderson says. "I hope that by 1990 we'll have more space, including additional seating, stacks, and materials storage."

Despite those spatial limitations, Gordon Library has been able to expand its resources in other ways. Located in a city with a vast array of college and university libraries, as well as specialty libraries at cultural institutions such as the Worcester Art Museum and American Antiquarian Society, Gordon Library is part of a cooperative which enables students to access 2,000,000 books within Worcester alone.

Formed at WPI in 1967 under the aegis of the Worcester Consortium for Higher Education, the Worcester Area Cooperating Libraries (WACL) comprises 14 local academic, public and specialty libraries. Through the Inter Library Loan program, students can borrow books from diverse resources; a daily shuttle service among WACL members makes most books available within 36 hours.

Anderson says Gordon Library lends about as many books as it borrows from other area institutions. "No library can be self-sufficient any more," he says. "We all need to cooperate."

In large part, the need to share materials has been brought about by the rising cost of books and the need for libraries to specialize in order to best utilize limited resources. Gordon Library's strengths, says Anderson, are in engineering and technology, as well as the basic sciences.

In turn, he says Clark University is a major resource for social science references, Holy Cross College for the humanities, and the University of Massachusetts Medical School for biomedicine and biotechnology.

Those three institutions do the most trading with WPI, though Anderson adds that Worcester State College's library is known for its education holdings, and Assumption College is the place to turn for books on languages and philosophy.

A quiet place to study is just the beginning of the comprehensive services Gordon Library provides; it now offers more than 1,300 magazines and journals.

Bill Denison

But the universe of lending institutions accessible to WPI students and faculty is not limited to the Worcester area. Two computer networks, one in operation and one still being developed, enable Gordon Library patrons to borrow books from thousands of libraries across the country.

Via the On-Line Computer Library Center (OCLC), users can search for reference material in more than 4,500 libraries by typing information about an author or title into a computer terminal. The system will locate the source; through Inter Library Loan, the user can place an order. Assuming the material in question circulates and is available, Anderson says it will arrive an average of seven to 10 days later.

The system's major shortcoming, however, is that it can only be used for title or author searches; information is not stored by subject. In addition, the data base indicates only whether a resource is part of a library's collection—not whether it is actually on the shelf or available for borrowing.

An alternative computerized cataloging system, which will enable the user to survey resources by subject, as well as title and author, is being developed on a regional basis through another library consortium—Central/Western Massachusetts Automated Resource Sharing (C/W MARS).

Thirty-four academic and public libraries, including Gordon Library, are members of the system, whose computer facilities are housed on the grounds of Anna Maria College in Paxton, Mass.

Ultimately, the consortium's Public Access Catalogue (PAC) will replace traditional card catalogs in member libraries. Rather than digging through drawers of index cards for appropriate references, users will type inquiries into a computer terminal, accessing titles in libraries throughout the C/W MARS system. In addition, the PAC will identify whether a book is already checked out, non-circulating, or available for borrowing. Books located at a different library could then be obtained through Inter Library Loan.

But that powerful research network is at least a year from being realized, according to Helen Shuster, Gordon Library's head of technical services and automation. Currently, Shuster says her staff are still in the process of entering all of the Library's holdings into the system data base.

An enormous clerical undertaking, that process was started 10 years ago, even before C/W MARS existed, when Shuster anticipated the need to begin cataloging books on computer tapes for some future reference system. Though most of the Library's resources have been entered into the data base, there is still the task of recording individual books in a series, such as volumes in an encyclopedia.

As other member libraries computerize their catalog information, work continues at the regional level to link the data bases together. "We know the computer hardware will work, but the software from C/W MARS [for the PAC] is still being perfected," says Shuster. "We're still very much in the planning process, though I hope the system will be available in the next fiscal year."

In the meantime, librarians are using C/W MARS for circulation control within Gordon Library. When students check out materials, that information is recorded within the C/W MARS data base. The system can also be used at present to search for titles within the Gordon Library, as well as within member libraries such as the University of Massachusetts Medical School and Clark University, which also have their collections on-line. The advantage of the PAC, once perfected, is that it will enable more searches and be more "user friendly."

Books are not the only items being cataloged on computer at the Gordon Library. Eighty years' worth of WPI undergraduate theses—part of the Institute's archives—are also being recorded on a separate data base by archivist Lora Brueck.

"Up to now, the information about each thesis was written on a card and grouped by class year, in alphabetical order," explains Brueck. "Now, as I look

at each thesis, I decide on the appropriate subject heading and enter that information into the computer. That way users will be able to do a search by subject or title."

Yet another important computerized research tool is the Online Search Service. A link to over 200 data bases nationwide, the system can access information as varied as U.S. government R&D reports, chemical research abstracts, or an index to the *Harvard Business Review*. Rates for data searches during business hours vary, but at night, students can use the End-User Search Service for $24 an hour.

Computers are available to students for a different purpose elsewhere in the Library. In the audio/visual room, VCRs and television sets share space with about a dozen AT&T microcomputers for student use. An adjoining room that has been set up for training WPI staff on the new DEC administrative computer is also open to students after hours.

Other computer resources are in the planning stage. Among the most intriguing developments that are changing the way libraries of the future will store information is the compact disk (CD/ROM). Like the small disks that are revolutionizing the recording industry, CD/ROM will eventually be used to store words, graphics, and even moving images.

Currently, bulky resources like *Books in Print* are available on compact disk. Shuster says disks are also being produced that contain not only entire encyclopedias, but also subject outlines with references to individual sections of the encyclopedia, to help users write research papers.

The advantages of such new technologies are obvious for a library where storage space is at a premium. But at the same time, with so many new options to choose from, Shuster says one of the greatest challenges is knowing what *not* to invest in.

"There is a danger of letting technology drive you in certain directions," she cautions. "Like going out and buying CD/ROM (information stored on compact disks) because it's there, without having any real need for the applications.

"But we also have to be very careful that other people don't take our jobs away from us. There are a lot of commercial enterprises in the business of providing information. We have to keep up with the technology and advances in automation, to make sure we have the services people need."

The key to making the right tradeoffs as Gordon Library begins its third decade, says head librarian Anderson, is flexibility. And the key to that—and what has enabled the Library to adapt successfully in the past—is the Library's staff and their commitment to service. "As change has come about, they've been willing to experiment and go along with the changes," says Anderson. "The Library's staff is outstanding."

Evelyn Herwitz, a freelance writer living in Worcester, is a frequent contributor to the Journal.

The Gordon Gallery

ARTWORKS as well as books fill the Gordon Library, from Laurence Sisson's acrylic "Ice Elegy," in the main lobby, to a life-size sculpture of a horse's head in the Music Room, to a wall of art on the third floor.

More than just decorations, the art collection is evidence that one of the Library's major goals is being fulfilled. Head Librarian Albert Anderson expressed it in a 1967 *Journal* article:

"[The] Library has been designed so that the student may view the best in contemporary art, architecture, and photography as well as works in the established periods of the past."

In addition to the Library's private collection, which includes many original prints from the Pratt Institute in New York and gifts from WPI alumni, special loaned exhibits are often on display. Sources range from the Smithsonian Institution to local and regional artists. To ensure good exposure, the works are shown along the third floor corridor. Comfortable benches are placed at intervals along the hall, providing a restful spot for meditation or a simple study break.

"Students and visitors respond very positively to the art and special exhibits," says Anderson. "This building is not just a library. It's a showplace."

President's Message
Continued from page 2

last 16 years. Interestingly, the recent WPI goal statement, developed and endorsed by the WPI faculty, includes the above criteria, albeit from a more technological perspective: "To lead students to develop an excellent grasp of fundamental concepts in their principal areas of study, to lay a foundation for lifelong renewal of knowledge, to gain a mature understanding of themselves, and, most importantly, to form a deep appreciation of the interrelationships among basic knowledge, technological advance, and human need."

The recommendation from the Carnegie Report regarding faculty scholarship is perhaps the most important goal for WPI in the coming decade. As Frederick E. Terman, former vice president and provost of Stanford University, eloquently said, "Quality is not produced by magnificent buildings nor is it assured by huge enrollments. It is not even based upon beautiful laboratories with expensive equipment. What counts is the quality of the faculty or, more precisely, the quality of those few members of the faculty who combine leadership in education with research qualifications in engineering and science. Outstanding faculty members will attract outstanding students who, under their influence, will be trained to make important contributions in higher education, industry and to society." Thus, to ensure its future, WPI must direct significant resources toward faculty development. There is no better way to guarantee continued quality and growth for the years to come.

The philosopher Alfred North Whitehead once said that the function of a college was "to preserve order amid change and to preserve change amid order." One dynamic that will most assuredly face all students in the future is change—rapid and in many ways uncontrollable. The students of today and of the years to come must be adaptable, yet also structured. They must be able to reflect the lessons of history as they make proper choices for the future. But they will also need to be able to ride a wave of technology that will be difficult to control.

To accomplish this, WPI will continue to develop the extraordinary undergraduate education embodied in the WPI Plan, but to do this WPI will need a group of exceptional scholars, able to conceptualize as well as teach. WPI's *Campaign for Excellence* is now in progress to help provide the resources necessary to support this new emphasis on scholarship as a foundation for the 21st century. The efforts and dedication of every member of the WPI family will be required during the next three years to attain the ambitious $52.5 million goal of the *Campaign* so necessary for WPI's important and exciting role as a premier independent technological university.

Dr. Jon C. Strauss is president of WPI.

Room with a View
Continued from page 12

ket," he notes, "so we've invested in resources like CAD systems."

Indeed, a tour of Data's facilities turns up computers of every size and shape: a room full of sales representatives log every phone contact by computer, engineers have them taken apart on tables, the marketing department has desktop publishing systems.

"What often happens," Molinari continues, "is that companies get so big that they become uncontrollable, and that's a failure of management. I think there's an optimum level where people can work well together, and when a company begins to get too big it needs to be broken down so that people are allowed to do what they do best."

The key is communication. "If you and I are working in a room together, it's easy to communicate. But what about when there's 10 people? Or 100? The way you communicate has to change. So we spend a lot of time and energy on trying to communicate effectively."

And they'll be spending even more time in the future. With one successful subsidiary currently operating in England, and plans to open a company in Germany this year and one in Japan next year, there's a lot going on. Data Translation's products are sold in 42 countries.

But, as with technology in general, Molinari says there is no end in sight.

"The challenge is to stay on top. It's really difficult. You have to be careful not to stop to pat yourself on the back. There's too much farther to go. We've only just scratched the surface."

Michael Shanley is a freelance writer living in Holden, Mass., and a frequent contributor to the Journal.

LETTERS

Editor:

I was both intrigued and distressed while reading Paul Susca's "The IQP" (Spring 1987). The article provides an interesting overview of some complex interactions between society and technology. My particular concern, however, lies in the treatment of the abortion issue by the students involved. Let it be clear that my goal is not to judge the students themselves.

Can a fetus truly be considered human life only if it can survive outside its mother's womb? Is the fetus "entitled to its right to life" only if it is 24 weeks or older? What about the rights of developing babies that are 23 weeks old, or 23 days old, or yes, even 23 seconds old? Would a 23-week-old fetus inside the womb suddenly become a human being because an apparatus that could sustain it outside the womb had just been developed thousands of miles away? How arbitrary is it to define human life according to the necessary means of sustenance or the latest advance in life support technology?

If a newborn baby were to die without a respirator, would it have to wait until being taken off of the apparatus before it could be considered human life? Does an adult cease being human life the moment it is placed on a respirator, without which it could not survive?

The human being begins growing at conception and continues to grow until adulthood. The heart of a fetus is beating at about three weeks, and brain waves have been recorded at 40 days. By the end of the first trimester, the fetus squints, swallows, kicks, sucks its thumb, and has fingerprints. Yet it is being suggested that it would be ethical to mutilate and destroy a further developed fetus!

The point to be made is that human life begins at conception and continues to develop until it reaches adulthood. To deny the right to life to a fetus or any other person at any point is a grave injustice. As Nobel Prize winner Mother Teresa of Calcutta has said, society cannot hope to save itself if it cannot attempt to save the lives of its youngest members.

Timothy J. Watkins '84
Naugatuck, Conn.

REUNION '87

Robert S. Arnold

with a splash of color
and sunshine

WPI Journal

ORCESTER POLYTECHNIC INSTITUTE AUTUMN 1987

Protecting the Environment

Science and the Engineer

Brian J. Savilonis '72, associate sor of mechanical engineering a women's cross-country coach, w out with his '87 recruits. Photo b Michael Carroll.

Staff of The WPI JOURNAL: Editor, Kenneth L. McDonnell • Alumni Information Editor, Ruth S. Trask
Alumni Publications Committee: Samuel Mencow '37, chairman • Paul J. Cleary '71 • Judith Donahue Sim '82 • William J. Firla, Jr. '60 • Carl A. Keyser '39 • Robert C. Labonté '54 • Maureen Sexton Horgan '83.

The WPI Journal (ISSN 0148-6128) is published quarterly for the WPI Alumni Association by Worcester Polytechnic Institute in cooperation with the Alumni Magazine Consortium, with editorial offices at the Johns Hopkins University, Baltimore, MD 21218. Pages I–XVI are published for the Alumni Magazine Consortium [Franklin and Marshall College, Hartwick College, Johns Hopkins University, Villanova University, Western Maryland College, Western Reserve College (Case Western Reserve University), Worcester Polytechnic Institute] and appear in the respective alumni magazines of those institutions. Second class postage paid at Worcester, MA, and additional mailing offices. Pages 1–14, 31–44 © 1987, Worcester Polytechnic Institute. Pages I-XVI © 1987, Johns Hopkins University.

Staff of the Alumni Magazine Consortium: Editor, Donna Shoemaker • Wrap Designer and Production Coordinator, Amy Doudiken Wells • Assistant Editor, Julia Ridgely • Consulting Editors, Elise Hancock and Alan Sea • Core Designers, Allen Carroll and Amy Doudiken Wells.

Advisory Board of the Alumni Magazine Consortium: Franklin and Marshall College, Linda Whipple and Patti Lawson • Johns Hopkins University, B.J. Norris and Alan Sea • Villanova University, Eugene J. Ruane and D.M. Howe • Western Maryland College, Joyce Muller and Sherri Kimmel Diegel • Western Reserve College, David C. Twining • Worcester Polytechnic Institute, Michael Dorsey and Kenneth L. McDonnell.

Acknowledgments: Typesetting, BG Composition, Inc.; Printing, American Press, Inc.

Diverse views on subjects of public interest are presented in the magazine. These views do not necessarily reflect the opinions of the editors or official policies of WPI. Address correspondence to the Editor, The WPI Journal, Worcester Polytechnic Institute, Worcester, MA 01609. Telephone (617) 793-5609. Postmaster: If undeliverable please send form 3579 to the address above. Do not return publication.

CONTENTS

WPI JOURNAL
Volume XCI No.2
Autumn 1987

2 **Accreditation: Why All the Fuss?**

A message from Provost Richard H. Gallagher

4 **But One Environment to Protect—Forever** *Evelyn Herwitz*

Bigger challenges and new technologies in the quest for a cleaner habitat.

11 **The Entrepreneurial Spirit: A Simple Story** *Michael Shanley*

That's how industrialist Raymond Perreault '38 sees his distinguished career.

I **Changing Work, Changing Times** *Julia Ridgely*
Illustrations by Amy D. Wells

In our increasingly competitive economy, the workday expands and free time shrinks.

VIII **Where the Rubber Meets the Road** *Donna Shoemaker*

Civil engineers pave the way for the structures we take for granted—until they fall or fail.

XVI **Freshman Disorientation** *Cartoons by Sid Harris*

Some comic moments on American campuses.

31 **Always Growing, Forever Changing** *Bonnie Gelbwasser*

The special challenges of collegiate physical resource management—and the people who meet them.

38 **In Praise of What Persists** *Paul Susca*

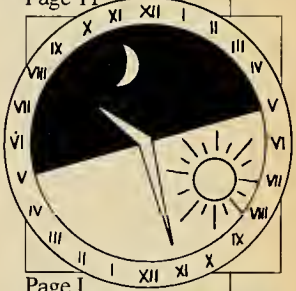
Why science continues to be vital to the education of engineers.

44 **WPI, Inc.** *Dr. Jon C. Strauss*

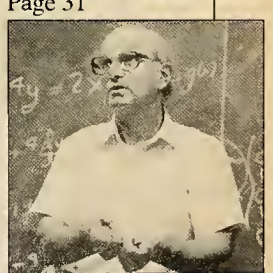
Explaining why the Institute and business have been friends for so long.

Page 4

Page 11


Page I

Page 31


Page 38

Cover: Dr. Frederick Hart, associate professor of civil engineering (right) and graduate students Wayne Wheeler and Suzanne Lewis, standing on the shores of Wachusett Reservoir, work to meet environmental challenges through advanced technologies. Story on page 4. Photo by Michael Carroll.

Accreditation: Why All the Fuss?

By Dr. Richard H. Gallagher

One of the feature stories in this issue of the *WPI Journal* discusses the role of basic science courses in the education of engineers. Although the article amply justifies instruction in these courses, it notes at the outset that the accrediting agency for WPI's engineering programs, the Accreditation Board for Engineering and Technology (ABET), has insisted on the presence of these courses in the curriculum.

Just who is ABET? you may wonder. What other conditions do they place upon programs seeking their imprimatur? How do they go about measuring institutional compliance with their criteria? In view of the fact that WPI is being visited by a team from ABET in 1987-88, it seems appropriate to discuss these and other related questions.

ABET was created some 55 years ago by action of the major engineering societies operating under the umbrella of the Engineers' Joint Council, with the support and encouragement of the engineering education community. It was known then as the Engineers' Council for Professional Development, but it has since changed its name to its current, more descriptive appellation. The term "technology" stems from the fact that ABET also serves to accredit institutions that offer programs leading to the bachelor of technology degree, which is more oriented toward "hands on" practice than the baccalaureate degree.

It is important to observe that ABET accredits *programs*, rather than institutions, and that accreditation, once it has been awarded, has a specified, limited life—generally three or six years. WPI might wish to refer to itself as being accredited in engineering because *all* of the programs for which it has sought accreditation are successful in that respect. However, in accordance with ABET policies, WPI must refer specifically to each program that is accredited. If one such program were to be denied accreditation, however, it would no longer be accurate for WPI to describe itself as "ABET accredited."

Michael Carroll

The engineering accreditation process has been a strong factor in building the stature of U.S. education in the profession.

When an institution's accreditation is up for renewal, an ABET visiting team pays a two-day visit to the campus. The team consists of a chairman and one visitor for each program, and occasionally visitors-in-training, as well as observers assigned by such organizations as the state professional engineering society and the state board of technical registration. A team of 15 or more in not uncommon at large universities. For WPI, with four programs (chemical, civil, electrical and mechanical engineering) seven to ten individuals might constitute the team.

When only one program is scheduled for a visit, the team might consist of just two persons—the team chairman and the visitor to the program being reviewed. This reminds me of a story associated with the legendary American Indian athlete Jim Thorpe. Someone assigned by the organizers of a major track and field meet to greet visiting teams was surprised when just two persons from the Carlisle Indian School stepped off the train. He asked if there were only two people representing the school. Thorpe replied, no, there was just one: "My companion is the team manager." Thorpe went on to win most of the events.

ABET's criteria for accreditation are both general and specific to the program being reviewed; the latter originate with the relevant major technical societies, such as the American Society of Mechanical Engineers. Looking at the total four-year undergraduate experience as eight semesters, ABET requires one semester of mathematics, one semester of science, two semesters of engineering science, one semester of design, and a semester of humanities and social sciences. Fully three-quarters of the curriculum is affected!

In addition, there are detailed requirements, bearing upon computing, writing, and communication. Certain students carry special obligations, such as ROTC. This helps to explain why a curriculum

Robert Raslavsky '78

that would span more than four years is widely discussed, and why suggestions for the inclusion of other, seemingly appetizing course requirements Shouldn't they learn to speak Japanese and grapple with ledgers like a veteran CPA?) fail to elicit much enthusiasm.

A visiting team also takes a careful look at institutional budgets, salary scales, faculty biographies, advising mechanisms, placement services, computing facilities, and laboratories and classrooms, among other things. They visit the library and supporting academic departments such as the sciences, humanities, and social sciences. They study the textbook used, the homework assignments, the examinations and grading policies, and talk to the students, faculty, and administration.

My own policy, in a seven-year stint as visitor to civil engineering programs, included visiting classes and holding discussions with the students present. Although an institution might view a visit with apprehension—and there is certainly a great deal of background work to be done before the team arrives—the visit itself is truly a grueling experience for those who conduct it.

Visits occur in the fall semester. The report of the team members passes through many hands and committees within ABET, emerging officially in the following June or July. Along the way, the colleges being examined are permitted to review and respond to preliminary versions of the report. In recent years, the criteria have been stringently applied. Of almost 300 programs visited in 1985–86, only 28 percent were awarded the maximum (six-year) term of accreditation. This was down from a high of 58 percent eight years earlier.

On the other hand, many observers argue that these statistics indicate an erosion of the quality of engineering education in the past decade, brought about by faculty shortages, inadequate equipment, and the striking rise in undergraduate enrollment. The number of graduates of accredited engineering programs has more than doubled in the past ten years, to approximately 80,000 annually.

Others believe, to the contrary, that there has been an escalation in the rigor with which the criteria are applied—otherwise known as "bean counting." Today, more facets of the engineering educational process are being looked at, and higher standards are being set. Some observers feel that the menu of requirements exceeds that which is actually essential for a good education in engineering. There is concern that this trend has worked to the detriment of innovative curricula, such as the WPI Plan, or of even less venturesome efforts.

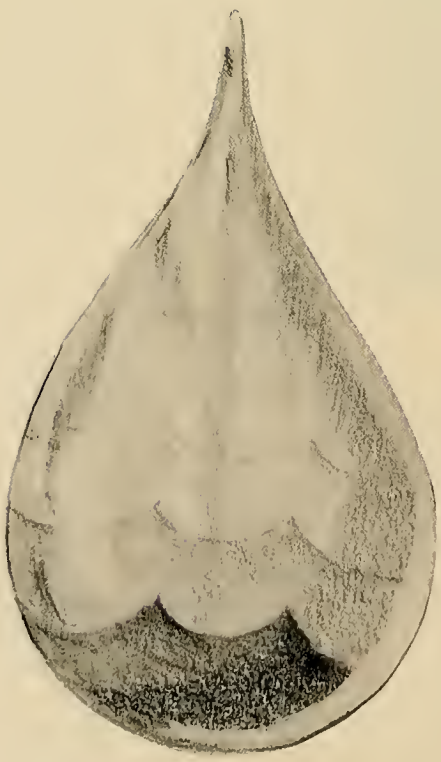
Pressure is growing for a more flexible interpretation of accreditation criteria, but at the same time there are standards to be set and met. If anything, the recent years have seen the expansion of diploma mills and commercial educational operations that seek to short-circuit the educational experience needed for a professional career.

In my view, the engineering accreditation process has been a strong factor in building the stature of U.S. education in the profession. It has been singled out for praise in a Carnegie Foundation study of such processes, which was otherwise critical of other disciplines, and it increasingly serves as a model for programs elsewhere in the world.

Richard H. Gallagher is provost and vice president for academic affairs.

But One Environment

Despite cutbacks in funding to protect the earth's environment, the need to safeguard our air, water, and soil has never been greater, as a growing number of WPI researchers are finding.



Amy D. Wells

By Evelyn Herwitz
Photos by Michael Carroll

A long, cool drink after a workout, a steaming cup of coffee on a brisk morning, a base for soups and gravies, a bath for vegetables, a rinse for toothpaste—drinking water is so much a part of our daily lives that we barely notice it.

But the apparent simplicity of water belies the complex chemistry of its production and distribution, particularly for large populations. In a city like Worcester, which draws most of its drinking water from a series of 10 reservoirs in surrounding towns, the risk of bacterial contamination is an ever-present concern.

Like many public water supplies, Worcester uses chlorine as its only line of defense. But knowing how much chlorine to add, and when and where in the distribution system to add it, is a mixture of art and science. Too little chlorine increases public health risks from water-borne pathogens; too much chlorine can foment the creation of carcinogenic organic compounds, trihalomethanes (THMs). Factors include not just the volume of water to be treated, but also the age of the distribution network and the degree to which pipes are clogged by decades of tuberculation—black goo that interferes with the chlorination process.

Finding a way to help municipalities solve the chlorine dilemma has been a major concern of Frederick L. Hart, associate professor of civil engineering. Working with undergraduate and graduate students for the past two years, including John L. Meader '86 and Shih-Ming Chiang, Hart has developed a tool that he believes can enable public water supply operators to fine-tune their chlorination process.

Called CLNET, the computer model simulates the decay of chlorine throughout a given distribution system. The information enables the operator to know where to put secondary chlorinators and how much chemical to use in order to maintain proper chlorine residual levels throughout the system.

Divided into an input processor (designed by Susanne Lewis '87 and Steven Woodard '87 under the supervision of Grace Crooker Levergood), a simulator (coded by Chiang and Meader), and an output processor (coded by Margaret Blastien '87, James Connell '87, and Russell Houde '87), the user-friendly program helps operators to create a data file tailored to their systems. Parameters include flow rates, diameters, and length of pipes. Results from the initial simulation, he adds, are compared with field observations, and the data file calibrated to improve accuracy of future simulations. Output is displayed in colored graphs and tables to make the information easy to read and interpret.

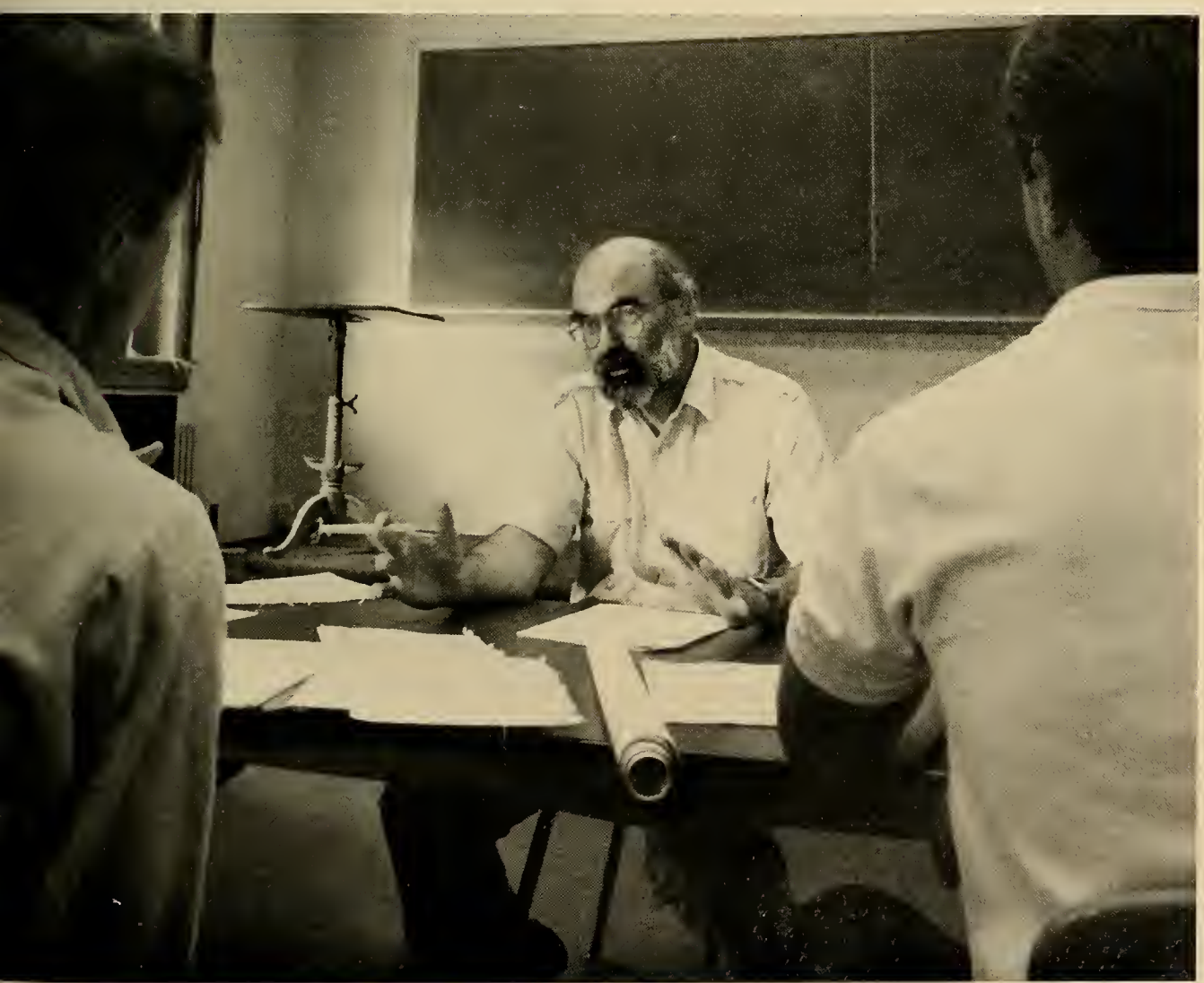
Requiring a 32-bit processor to handle all the data during the simulation, CLNET has been developed at a time when proposed federal regulations may tighten already tough standards on THMs. "A lot of water companies are having trouble maintaining the current standards," says Hart. "And the upcoming

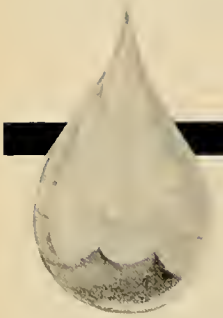
to Protect—Forever

regulations are even more stringent. Municipalities will have an extra impetus to regulate chlorine use.

Hart is one of a handful of WPI faculty engaged in environmental research, an area that has experienced tremendous swings in funding support and student interest over the past two decades. Although the field is no longer as trendy as it was in the late 1960s, research into environmental problems is, at the same time, no less critical to world survival. And despite cutbacks in government-funded research, issues like hazardous waste disposal and groundwater contamination present some of the toughest and most important scientific and engineering challenges to be faced in contemporary life.

"Urban improvements are often made without thinking that water has to go someplace," says Dr. Malcolm S. Fitzpatrick, shown here with two Major Qualifying Project students. An associate professor of urban and environmental planning, FitzPatrick describes urban planning and environmental planning as "two sides of the same coin."





Wetland protection and soil erosion control have been the focus of several student projects. Three students are laying the groundwork for an open space and recreation plan for the nearby town of Spencer. Of concern is the adequacy and location of the town's groundwater supply and drainage system. Another student project involves studying the impact of water contaminated by heavy metals on fish in the Nashua River.

Because the issues are so significant, Professor of Civil Engineering Kris Keshavan believes environmental research and the field of environmental engineering are beginning to experience renewed interest.

"Environmental concerns are coming back," asserts Keshavan, "but not at the fanatical, frenzied level of the late '60s and early '70s, which I think probably hurt efforts more than it helped."

Head of Civil Engineering from 1976 to 1986, Keshavan recalls the environmental movement's heyday as a period when "many articles were written and papers published without much understanding of the problems." It was also a time, he says, when "everyone wanted to be an environmental engineer." Department enrollment swelled to 120 students, making civil engineering the second largest department on campus.

But following the Vietnam War, the lure of lucrative high-tech jobs began to draw students in new directions. "Everyone drifted to electrical engineering, and our enrollments plummeted to a third of what we'd had before," says Keshavan. Though the energy crunch sparked some renewed interest in the field, he notes, the prospect of somewhat lower salaries compared with "higher tech" industry discouraged many students from pursuing a career in environmental engineering.

In a dynamic economy, however, things are bound to shift again. And Keshavan sees evidence that the pendulum has begun to swing back in his direction. "Jobs are going begging for graduates and salaries have increased," he observes. "Students getting into environmental engineering now are doing themselves a favor."

Once again pursuing his own research, Keshavan has turned his attention toward developing and perfecting innovative technologies for wastewater treatment.

Many modern municipal sewage treatment plants currently employ traditional sludge treatment processes such as sludge digestion, sludge dewatering, and incineration. Another sludge treatment process used in several cities is the Zimmerman process, which involves oxidizing wet sludge under high temperature and pressure. These well-developed technologies, Keshavan says, require significant energy levels and space. Their by-products include odor-causing compounds, which can make life unpleasant for those unfortunate enough to live down wind.

A new, alternative approach is the deep-shaft wet well oxidation process. As its name implies, this method of treating wastewater sludge involves drilling a foot-wide, mile-deep hole, which is then cased with stainless steel. When liquid sludge is pushed through the tube, the pressure at the bottom rises significantly. Once the oxidation process is started, Keshavan says, the temperature will remain high enough for the system to be essentially self-sustaining. Energy requirements are negligible, and this wet incineration process creates no air pollution.

"It's a very attractive system for locations like Deer Island [in Boston Harbor], where there is little space," says Keshavan.

Sewage treatment is also a research priority for Keshavan's successor, department head James C. O'Shaughnessy. Coming to WPI from Northeastern University's civil engineering department, O'Shaughnessy says he plans to involve undergraduate and graduate students in studies of advanced wastewater treatment processes.

"We'll be looking at ways to remove nitrogen from wastewater prior to its discharge into the groundwater. The methods we're investigating require few modifications or additions to wastewater treatment plants," says O'Shaughnessy, who also specializes in treatment methods for industrial wastewater and hazardous wastes.

O'Shaughnessy will be sharing this fall's project work with Fred Hart, who, in addition to developing CLNET, has involved students in another kind of wastewater research. Working with Kristin Nygard '87 on a project begun when Hart worked for a Wellesley engineering firm, he has calibrated a computer model of groundwater flows and pollutant transport beneath Barnstable, Mass., on Cape Cod.

The problem, in this case, stems from the fact that Barnstable, like many Cape communities, is experiencing rapid growth but uses its underground aquifer as its sole water supply source *and* as a wastewater disposal sink. Homes depend on septic systems for wastewater disposal, while the town operates a municipal secondary wastewater treatment facility which discharges about one million gallons of effluent directly into a sand bed. Though the sand acts as a natural filter, Hart says, the town has become concerned that increased municipal wastewater may cause a plume of nitrate contaminants to flow underground into the town's nearby wellfields.

To study the plume's movement, Hart and Nygard used a

"We'll be looking at ways to remove nitrogen from wastewater prior to its discharge into groundwater," says Dr. James C. O'Shaughnessy (left), head of the Civil Engineering Department, who plans to get students involved in studying advanced wastewater treatment processes. O'Shaughnessy and a student created a computer model of groundwater flow in a growing Cape Cod community that uses its underground aquifer as its water supply—and its waste disposal system. After finding that plumes of waste were drifting toward municipal wells, O'Shaughnessy recommended building sewers to limit the use of septic tanks.

three-dimensional, computer-generated contour map of the town's water table. Bumps in the contour map indicate the plume's location, while dimples show where wells are drawing groundwater.

Projections based on population growth and discharge data revealed that the plume is traveling toward the south and southeast, potentially affecting several municipal wells. Nygard notes that Barnstable's options include building sewers in the southern area of the town to limit the addition of septic tank wastes to the plume, and more extensive treatment of effluents.

That kind of interaction and conflict between economic development and the environment is one of Malcolm FitzPatrick's primary concerns. An associate professor of urban and environmental planning in the Civil Engineering Department, FitzPatrick describes urban planning and environmental planning as "two sides of the same coin."

To illustrate his point, FitzPatrick cites the problems that development creates for soil erosion, particularly in wetland areas. "Urban improvements are often made without thinking that water has to go someplace," he observes. "Subdivision developers cut down trees and build roads, while ignoring the fact that trees and other vegetation help to hold water and put it into the ground. As a result, you get increased flooding and erosion downstream."

Wetland protection and soil erosion control have been the focus of several student projects supervised by FitzPatrick. In one ongoing project, Mark Nelson '89, Valentino Tocci '89, and Mark Czerepuszko '89 are laying the groundwork for an open space and recreation plan for the nearby town of Spencer. Among the topics being researched are the location and adequacy of the town's groundwater supply and natural drainage system.

"The drainage system is the basis of forming an environmental plan," explains FitzPatrick. "By protecting that, you pro-

vide open space and protect the town's water resources."

Other student projects have included a study of the environmental impact of cluster subdivisions for the Nashua River Watershed Association (NRWA).

The NRWA also has benefited from student project work supervised by another environmentalist on the WPI faculty. Robert Wagner, professor of chemical engineering and a member of the Institute's faculty since 1949, has been an enthusiastic proponent and advisor for student projects dealing with the environment.

Officially retired from WPI last December, Wagner—known fondly to his students as "Daddy Wags"—remains on campus this fall to supervise the department's unit operations lab. An avid mountain climber who scaled his first peak at age 44, Wagner has linked his love of nature with his work, both through founding and guiding WPI's Outing Club and through a vast array of student projects.

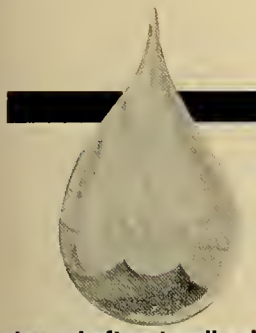
For the NRWA, one of Wagner's frequent project clients, student research has ranged from developing a canoe guide to a study of tumors found in some of the river's fish.

The latter project, which Wagner co-advised with Daniel Gibson, assistant professor of biology and biotechnology, drew on the resources of state environmental officials as well as the Smithsonian Institution.

The research problem, explains Wagner, stemmed from a discovery of heavy metals in river sediments. "We were concerned as to whether the heavy metals were causing cancerous tumors in fish," he says. With the help of state fish and wildlife authorities, fish were procured from those sections of the Nashua where sediments were known to be most contaminated.

Examining tissue segments in the laboratory, students Eileen Brown, Neil Garnache, and Musfik Konuk found "many tumors" on the lips and livers of the fish. But the question remained as to whether the tumors were malignant. "The kids

Head of Civil Engineering from 1976 to 1986, Dr. Kris Keshavan (left) recalls the environmental movement's heyday as a period when "many articles were written and papers published without much understanding of problems." It was also a time, he says, when "everyone wanted to be an environmental engineer." But following the Vietnam War, the lure of lucrative high-tech jobs began to draw students in new directions. "Everyone drifted to electrical engineering, and our enrollments plummeted to a third of what we'd had before," says Keshavan. Today, the pendulum is swinging back.



Most conventional methods of sewage treatment involve high levels of energy, require a great deal of space, and create by-products that include odor-causing compounds. But a new technique, deep-shaft wet well oxidation, is self-sustaining and produces no air pollution. In the process, a foot-wide, mile-deep hole is lined with stainless steel. Liquid sludge is pushed through the tube, and the resulting pressure causes oxidation at the bottom.

got in touch with the Smithsonian," says Wagner. "They asked us to send the removed livers to determine if they were cancerous. So we sent sections of the worst ones down to Washington." The findings from the Smithsonian were, fortunately, less dire than expected: "None of the tumors were cancerous," says Wagner. "They were still caused by the heavy metals, but weren't cancerous."

Another recent project concerning fish also involved the Nashua River. A tributary of the Merrimack River, the Nashua not long ago was deemed too polluted to support Atlantic salmon. As a result, when federal game officials began restocking the Merrimack with salmon, they decided to avoid the Nashua altogether, a move which greatly frustrated NRWA members.

For help, they turned to Bob Wagner and WPI undergraduates David Kolstad and Gregory Tashjian. "First we went to most of the towns along the Nashua to gain evidence that in earlier years, Atlantic salmon ran the river," Wagner says. "But the latest reports dated back to the 1860s, before power dams stopped the salmon."

Armed with proof that the river had, at least 100 years ago, supported salmon, the students next began to research the federal government's decision not to restock the Nashua. "They had based their decision on a report that was more than ten years old," says Wagner. "But the Nashua had been cleaned up tremendously in that time. So we got the state to analyze the river, and it found that the water quality is now up to standards for stocking salmon."

That project, one of Wagner's favorites, earned him and his students a letter of commendation from state officials. "It was a very interesting project," he recalls with a smile. "I feel we did some good there."

Another memorable project involved a very different and rather forbidding locale, the top of New England's highest mountain, 6,288-foot-high Mt. Washington. There, several

Dr. Robert E. Wagner, professor emeritus of chemical engineering, has worked with scores of students on environmental projects ranging from studying pollution in the Nashua River to building cloud collectors to test for acid rain.

years ago, Appalachian Mountain Club (AMC) research director Dr. Kenneth Kimball had been frustrated in his attempts to measure the acid content of clouds that envelop the summit most of the year.

The problem was significant because the cloud-water data was being used to test a pioneering hypothesis in acid rain research: the idea that fog particles contained in clouds are more acidic than rainwater. If true, the theory would help explain why red spruce atop New Hampshire's White Mountains were dying, while vegetation in the valleys below showed no signs of similar damage.

Working with Cornell University's Dr. Gene E. Likens and Dr. F. Herbert Bormann of Yale University, the AMC had placed cloud-water collectors at two White Mountains locations: Greenleaf Hut on Mt. Lafayette and Lake of the Clouds Hut in a col, or pass, between Mt. Washington and Mt. Monroe. But severe weather and high winds plagued the collectors from the start, rendering data unreliable.

Enter Wagner, himself a past AMC vice president, and four students: Andrew Cott '85, Bruce Daube '84, Reynold Dodson '85, and Peter Lamar '85. The students' mission, which included a seven-week term at Lake of the Clouds Hut, involved designing and testing a better cloud collector.

As things turned out, the students' design was so effective that Likens and Bormann offered two of the students, Daube and Lamar, a $10,000 grant to build 12 more collectors to be placed at sites from Alaska to Puerto Rico. The students' accomplishments still give Bob Wagner good reason to glow with pride when recounting their story.

"I've just had wonderful students," he says, summing up his years of advising. "They've produced fantastically."

Challenging projects such as these are certainly the stuff that can draw students into the field of environmental engineering. And, thinks Malcolm FitzPatrick, exposing students to the complexity of real world environmental problems is critical to developing their ability to devise realistic solutions that will do more good than harm.

"Flood control is not just a question of building a new dam," says FitzPatrick. "First you have to understand how the natural system works and the alternatives available for flood prevention. Then if you alter the system, you realize the constraints of that system and the potential impacts.

"Students can get discouraged taking environmental courses when they discover that many problems are so large that they cannot be handled individually. We've got to train engineers to work together to solve these problems, not just provide them technical solutions. They have to develop an ongoing understanding of the environmental system as a whole first."

Evelyn Herwitz, a freelance writer living in Worcester, is a frequent contributor to the Journal.

THE ENTREPRENEURIAL SPIRIT

EIGHTH IN A SERIES

No big deal, nothing fancy—that's how Falls Machine founder Raymond Perreault '38 would have his life story read.

A Simple Story

By Michael Shanley

Photos by Robert S. Arnold

Ray Perreault doesn't really want to have a story written about him.

"There's no story here," the self-effacing 73-year-old tells me when I call to set up an interview. "I'm not an intellectual or an inventor or anything like that."

It's not false modesty that prompts this response, but rather a genuine concern that he not be portrayed as anyone other than who he really is.

When I arrive in Chicopee to visit Perreault at the Falls Machine Screw Company, the attitude hasn't changed.

"I'm nothing special," insists Perreault, founder and president of Falls Machine. "I can't imagine why anyone would want to read anything about me."

He's reluctant to talk about himself, but in the course of a tour through the Falls Machine plant, where he can discuss equipment, production, and precision, he warms to the subject. Slowly, a portrait emerges of a man who sees himself as the product of heredity, environment, and circumstance.

To Perreault, success is more a matter of determination and desire than brilliance and creativity. In that sense, he is something of an everyman among those who built businesses in the years following the Depression. Nothing flashy, you see, just a lot of hard work, a certain sense of intuition, and a couple of decent breaks.

If it's hard to get Ray Perreault to talk about himself, it's easy to get him to give others credit, and one of his favorite topics is WPI.

"That's the real story," he says from his simple office in the one-story structure that houses Falls Machine, "WPI and what it's done for people, the role it's played in people's lives. I honestly believe that. What you see here had its roots at WPI."

As if to underscore his words, the wall behind his desk holds several sketches of the college, as well as a WPI calendar. While most people have good feelings about their alma maters, it's unusual to encounter such genuine passion in an alumnus.

Part of the reason dates back to childhood, which is when Perreault's memories of WPI begin. He grew up in the Newton Square section of Worcester, just down the street from the college.

"It seems that Worcester Tech was always a part of my life," he recalls. "We'd go over there and swing golf clubs on the fields—if they didn't kick us off—and ski down the hills in the winter."

Perhaps a more telling memory involves the old Washburn Shops. "I used to sit on the window sill and watch them working," says Perreault, a trustee and scholarship fund sponsor at WPI. "And I remember that very clearly."

He paid tribute to the memory by funding a machining module in the new Washburn Shops when they were renovated several years ago.

Perreault also credits his family background and upbringing for setting him on a course that would ultimately involve manufacturing. His grandfather was a mechanic, and his father, Henry, was in the jewelry business in Worcester. So Ray and his four brothers grew up in an environment where things were designed, assembled, and repaired.

"When I was a kid living on Roxbury Street," Perreault muses, "I remember delivering papers on my route. I was about 12 years old. One day I stopped at a house, and there was a motor wheel on the back of a bike. It was covered with cobwebs. I asked the lady about it and she sold it to me for eight bucks. I took it home and pulled it apart, then put it back together. I put it on the back of my bicycle and we'd run it down the street at 35 miles an hour.

"After that, I bought a near-a-car, a little one-cylinder thing that looked like a bicycle. And I used to take it all apart. The next thing I knew, my brothers would come home with a 1930 Ford, a used one, a wreck they bought for 35 bucks, and we'd fix that up. So I got oriented toward that kind of thing early in life.

"My father was one of the first people in Worcester to have an automobile, and back in those days, you didn't drive anywhere without a mechanic. He always encouraged us when we were working on things, but he never told us what to do. He'd make us do it ourselves.

"So if you ask how I happened to get into the business I'm in, I say, 'Who knows?'" Perreault continues with a good-natured shrug. "Why does someone end up a writer, or anything else? There's something in our genes that leads us in a given direction. In a certain sense, it's just in the blood."

For nearly 50 years, through good times and bad, Perreault has provided direction for Falls Machine.

WPI also turned out to be in the blood, in a manner of speaking. Perreault's older brothers, George and Harvey, both graduated from the college (classes of '30 and '33, respectively). When the time came for Ray to decide what to do with his future after high school, he followed in their footsteps.

"I was actually more interested in the business end of things than the mechanical," he explains. "But I went to WPI because it was the Depression, and that was an easy way to get a good education and to learn discipline."

After graduation, Perreault took a job briefly with Matthews Manufacturing and then with Wright Machine Company, which, like Perreault's current firm, makes screw machine products. It was there that he met Raymond Chevalier, who would become his partner in founding Falls Machine.

"It was 1939 and everyone told us we would fall on our faces," says Perreault, who funded his share of the start-up costs with money borrowed from his parents. "And we damn near did just that. Just after we got through the normal start-up problems any new company encounters, the war started and restrictions were placed on civilian manufacturing. It was a struggle."

The young company, founded in Chicopee on Chevalier's suggestion, survived by making parts for firms that built such military products as guns, trucks, and walkie-talkies. "In those days," he says, "I'd put in 60- or 70-hour weeks—

scheduling work, designing tools, making layouts, pricing, talking with customers."

Originally, Falls Machine had 20 or so employees, although it would later expand to about 40, the level at which it stands today.

"We've had the normal ups and downs," Perreault says in looking back over the company's history. "We go with the economy. When times are good, we swing with it and take advantage of it. When times are bad, we survive by belt-tightening. You just do the best you can."

Perreault is quick to credit Chevalier, who served as both a teacher and a role model. He also notes that his brother Harvey, who was with the company for several years before retiring in 1981, provided a boost.

But Chevalier retired in 1959, and his brother was with him for less than a decade. So while Perreault downplays his own role, it's clear that in the overall scheme of things the company has been a reflection of one man. (One man, Perreault would add, who relied on the full support and patience of his wife, Ina.)

From the outset, Falls Machine has concentrated on high-quality precision work. It produces parts for all types of companies, from high-tech electronic firms to paper conversion companies to sporting gun and hardware manufacturers. By design, the company has not expanded to compete for huge, mass production orders.

"We're like a restaurant that has a regular clientele," he explains. "Our customers stay with us and we stay with them. They pretty much determine what we do."

Falls Machine specializes in product orders that often call for tiny bevels, flattened sides (centerless grinding), or precise roll threading—details that require a combination of automatic machining and hand work.

The machine screw industry itself represents a segment of manufacturing that hasn't changed dramatically, even during the last couple of decades with the advent of the computer revolution. As Perreault notes, the new machinery housed in the shop today is pretty much the same as the equipment he bought decades ago—just more expensive.

"The toughest times were the late 1940s, after World War II," Perreault says, charting the company's history since its founding, "and then again in the late '50s and early '60s."

The machine screw industry has seen little change in the past few decades. It still demands extreme precision and a combination of machine and hand work.

The nature of Perreault's business is such that production increases during wartime. So his reaction to the 1960s and the Vietnam War tells more about Ray Perreault the man than Ray Perreault the businessman:

"The personal tragedy was so severe," he says. "If you talk to the boys who went over, none of them wants to discuss it. It was a horrible experience to subject anyone to.

"It was tragic what that war did to us. And the inflation that resulted seriously damaged the economy."

Since the mid-1970s, Perreault says, Falls Machine's biggest challenge has been dealing with that inflation. In general, however, the last decade has seen fewer peaks and valleys and more stability.

The expansion of its grinding operation allowed the company to do more precise work in-house. It was during this period that the production facility was expanded and the work force doubled to its current mid-40s range.

"Movement to that plateau enabled us to be more flexible and do better quality work," he explains.

More importantly, it allowed Falls Machine to take on more difficult jobs during a period when demand for complex, high-precision parts was increasing. "There weren't that many other shops that could do those kinds of jobs, so expansion helped us through what otherwise would have been lean years."

It was a textbook case of adaptation to a changing marketplace, but Perreault refuses to take

Perreault confers with a technician at the Falls Machine factory in Chicopee, Mass.

much credit for the accomplishment.

"I think any business can stay afloat if it really wants to," he says. "It's a matter of sound judgment and determination."

While Perreault believes that a conservative business approach is vital, he's the first to point out that in his own case, he thinks he overdid it on more than one occasion.

"I could have been more courageous in some instances," he admits. "The conservative part of me was a result of the Depression.

"But I don't feel cheated at all. I feel very fortunate to have gotten into business doing something I like, and to have had the chance to make a contribution by producing good parts for people."

Perreault truly does enjoy the business, a business that might appear mundane to outsiders. After touring the production facilities, however, it's easier to understand the attraction. It has to do with a fundamental nature of the operation: Out of an environment that must by its character be noisy and oily and, for some workers at least, boringly repetitive, there is at heart a transformation of basic metal into wonderfully tooled, utilitarian parts. It's a variation of the spinning of straw into gold. And to see, at the end of the production line, a boxed set of paper-cutting parts, for example, in their gleaming fine detail, is to see a thing of beauty.

So the key, Perreault would say to an aspiring young engineer, has to do not with salaries and trends, but with joy and simple satisfaction.

"You try a job and if you're not content, you try to figure out why," he explains. "Then you give yourself a kick in the butt and move on as fast as you can. And you do that until you find something that you enjoy.

"So many people talk to me about retirement," he continues, "and I can't fathom why people would want to retire unless they're unhappy in what they're doing. Then I begin to feel sorry for them for spending 40 years of their life doing what they didn't want to be doing. What a waste."

Coming out of WPI, Perreault felt a complete distaste for the typical manufacturing environment of the day.

"So when I had my own business, I set out from the beginning to create an environment where there was adequate lighting, proper tools, clean rest rooms, a place to sit down and have a sandwich—the simple things."

Such an attitude has given Falls Machine a stable work force over the years, and a good reputation in the community.

Perreault's one concession to advancing years is a slightly reduced workload. "A good friend of mine called me a fool 15 years ago," he recalls. "And when I asked why, he said, 'Pardon me for saying so, but you're still at the center of things too much. You haven't learned how to delegate.' And he was right. So I've learned. Now, if I'm not here for the day, I know the business goes on."

As I am about to leave, Perreault makes a few things clear for the record.

"Keep it simple," he says of the story, "because it is simple. I've had fun. I haven't invented anything. I haven't designed or built anything that would mean anything to most people. It's been just a little bit every day."

Michael Shanley is a frequent contributor to this magazine.

Nine-to-five is no longer the routine for Americans trying to reconcile the demands of the marketplace with the needs of family and personal life.

Changing Work, Changing Times

By Julia Ridgely
Illustrations by Amy D. Wells

There are offices at which 5 p.m. passes with little recognition, where a thin stream of employees trickles out until 9 p.m. There are offices where lights burn on the weekends and staff members spend evenings at company dinners and Sunday afternoons with clients. And there are homes in which parents sit in front of the computer long after the children are in bed.

Working late is nothing new, but changes in the economy have made it more necessary, even as the demands of the two-career family have made it more difficult. The growth of the service sector, the rising cost of living, and the move toward non-salaried labor are transforming the economy. Along with a society dominated by industry, the 40-hour, five-day work week is vanishing, and in its place is rising a week without weekends and work days running into nights. People work at midnight, shop for clothes on Sunday, and pick up their laundry late Tuesday nights.

On a national scale, the changes are about productivity: To be competitive, companies need to get the greatest amount of work for the smallest investment. On a personal level, the changes center on time—time to secure a place in an increasingly unstable job market, and time at home to enjoy the lifestyle the job is supposed to support.

These two absolute needs are clearly in conflict, and the battleground for the two antagonists—work time and home time—has so far been the individual lives of American workers. As a partial solution, companies and unions have proposed alternative work schedules like flextime and the four-day week. But so far, few workers have benefited from these innovations; a May 1985 survey by the Bureau of Labor Statistics (BLS) showed that only one in eight full-time workers had a schedule that was at all flexible. Meanwhile, more Americans are working overtime, moonlighting, and taking work home. During the BLS's sample week, more than eight million workers did at least eight hours of work at home; most held full-time jobs. Some 5.4 percent of all workers held more than one job, the highest level in 20 years.

"There's a real conflict because companies want more from their employees, but young people in particular want more leisure hours," says Dan Rees, associate professor of sociology at Western Maryland College (WMC) and a consultant to small businesses. "People are basically working to enjoy life. When a job becomes life, and when life falls out of balance, it can lead to frustration." There are people who thrive no matter how much they work, he says, "but they're the exception."

The leaner, meaner service economy

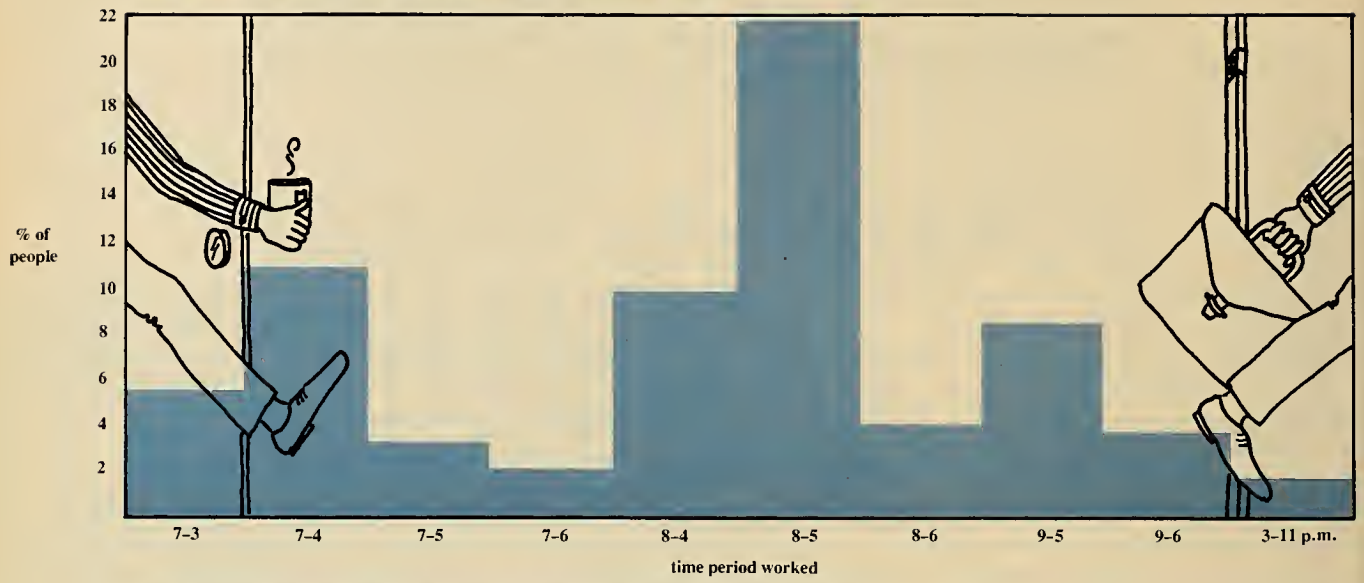
THE BOUNDARIES of work in a factory are clear: a certain number of hours and a certain rate of production equal so many items manufactured. Being at work means taking your position on the line; when the shift ends and the whistle blows, you may go home.

The majority of Americans, however, do not work in industry. While certain areas of manufacturing, like steel and autos, have been hit hard by foreign competition, the total number of jobs in industry has not decreased. But the proportion of people employed in industry has been declining steadily. The BLS reported last year that while 60 percent of employed people worked in the goods-producing sector in 1959, that figure had dropped to 28 percent by 1984. The BLS also predicted that nine out of 10 new jobs to be added by 1995 will be in the service sector; "miscellaneous" services (including business, personal, and medical) will account for one out of every four jobs in the United States by 1995.

"With the shift to the service sector, clients, not products, become the main form of how you cultivate business," says Ellen Auster, an associate professor in the management of organizations department at Columbia University. "It's not a question of what you make, but what service you sell."

Establishing a good relationship with clients can mean breaking down the barriers between work time and personal time, as well as between business and pleasure. "In the service industries, you end up going out to their houses, taking them out to dinner, playing golf, and so

The most common daily schedules of full-time workers



Times are rounded to nearest hour: 9 a.m. can be any time between 8:30 and 9:29. Wage and salary workers only.

on," says Robert Stokes, director of the Career Development Center at Villanova University and a business consultant. "The further you go up the ladder, the more you have those additional responsibilities."

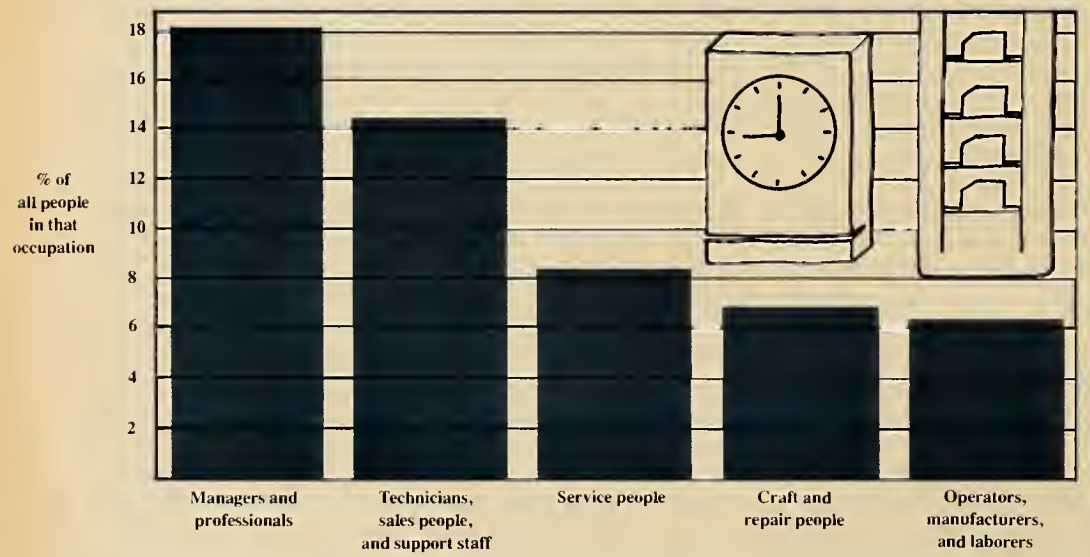
The service economy demands more from individual workers than a heavy load of business lunches. As part of the effort to make American business more competitive by cutting back on overhead costs, many companies are undergoing "restructuring." This umbrella term covers, among other things, combining jobs and departments with similar functions and wholesale cutbacks of full-time employees. Elimination of redundant managerial positions is one of the most feared side effects of mergers. The BLS reported that between 1981 and 1985, nearly 500,000 executive, administrative, and managerial employees lost jobs they had held for three years or more. Of those, 72 percent have found new jobs, but they have lost the fringe benefits that come with seniority.

Paring down management saves money; so does having a work force that can be hired or fired as the need arises. These ideas form the base for a "two-tiered" system for business, one in which a select few will hold full-time jobs with their attendant perks and benefits. This privileged inner circle will set policy and make decisions, while a transient force of part-time and "contract" employees will carry out day-to-day business. Since the early 1970s, Motorola, Inc., has divided its 90,000 employees into those with 10 years' seniority and total job security (30 percent), regular employees (40. percent), and a contingent force on six-month contracts that may be laid off on 24 hours' notice.

Rodney Austin, a WMC alumnus and trustee whose 34 years with R.J. Reynolds included 25 as senior vice president of human resources, sees restructuring as a herald of the last days of the golden age of American prosperity. While the economy was rock solid and jobs were plentiful, he says, workers reaped the benefits of salary, leisure, and security with little sense of how great a windfall they were receiving.

"I think we have had a tragic, sad period of generally lackadaisical attitudes among many in the work force," Austin says. "I don't want to imply that everybody's attitude is bad, but I do believe that it's the affluence of our

Who has flexible schedules?



Statistics excerpted from the U.S. Bureau of Labor Statistics' May 1985 supplement to the Current Population Survey.

times. Paraphrasing Mr. Churchill, never have so many had so much for which we did so little and have been so ungrateful. We've been here, by chance of birth, at a time of huge payoff coming for our work force."

Austin points out that the change is reflected in the most basic attitudes toward work. In previous decades, he says, young people entering business sought job security in the form of a long association with a powerful corporation. Security meant a good salary, a good lifestyle for the family, and plenty of vacation time. Now such a goal may be beyond the reach of all but the most driven.

"The bigger the corporation was, the better the security," he says. "As part of the restructuring not only of individual companies, but of world economies, that is no longer going to be the case. There will be a small, corporate structure of perhaps 30 to 50 key people, and you will contract out the rest. The parking lots will still be full, and people will be rushing in at 8 a.m. People will work on a skill basis and be competitive in that sense. The ultimate promotion would be to the 'politburo' of the corporation."

To move up in such a competitive environment requires dedication, and one of the most visible ways to prove dedication is working long hours. Like the "organization man" of the 1950s, ambitious workers of today try to send a message that nothing comes before their job.

"Face work"—using your physical presence as proof of dedication—"is still around, and, if anything, worse," says Ross Webber, professor of management at The Wharton School of the University of Pennsylvania. Webber believes that young professionals making high salaries are particularly prone: "To show that you're worthy of the money, you work these horrendously long hours without any overtime pay, or with the informal understanding that, although you're entitled to overtime, you're supposed to eat it."

Korn/Ferry International, an executive recruiting firm, surveyed 1,362 senior executives at top corporations in 1985. The average executive put in 56 hours a week, three hours more than in 1979. But working late to score points can be propagated all the way down the corporate ladder. Employees who see a supervisor staying past 5 p.m. take it as a hint that they should do the same. "That has an incredible effect on you," says Helen Vassallo, M.D., associate professor of management at Worcester Polytechnic Institute (WPI). "You're saying to yourself, 'If my boss stays late and takes short coffee breaks, of course he or she is using modeling to influence my behavior.' "

Extreme dedication, desire for promotion, studious efforts to please those in power—it all sounds like a return to the gray-suit-and-briefcase world of television programs like "Ozzie and Harriet." The difference, of course, is that sometime between then and now, Harriet went to work.

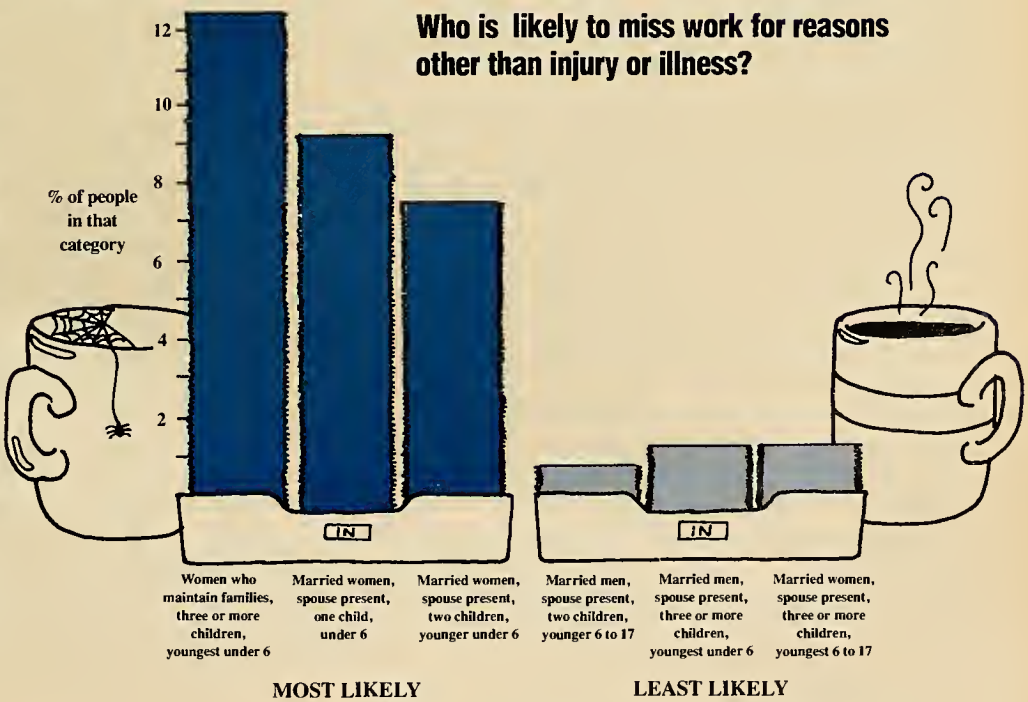
Women and flexible hours: a risky tradeoff

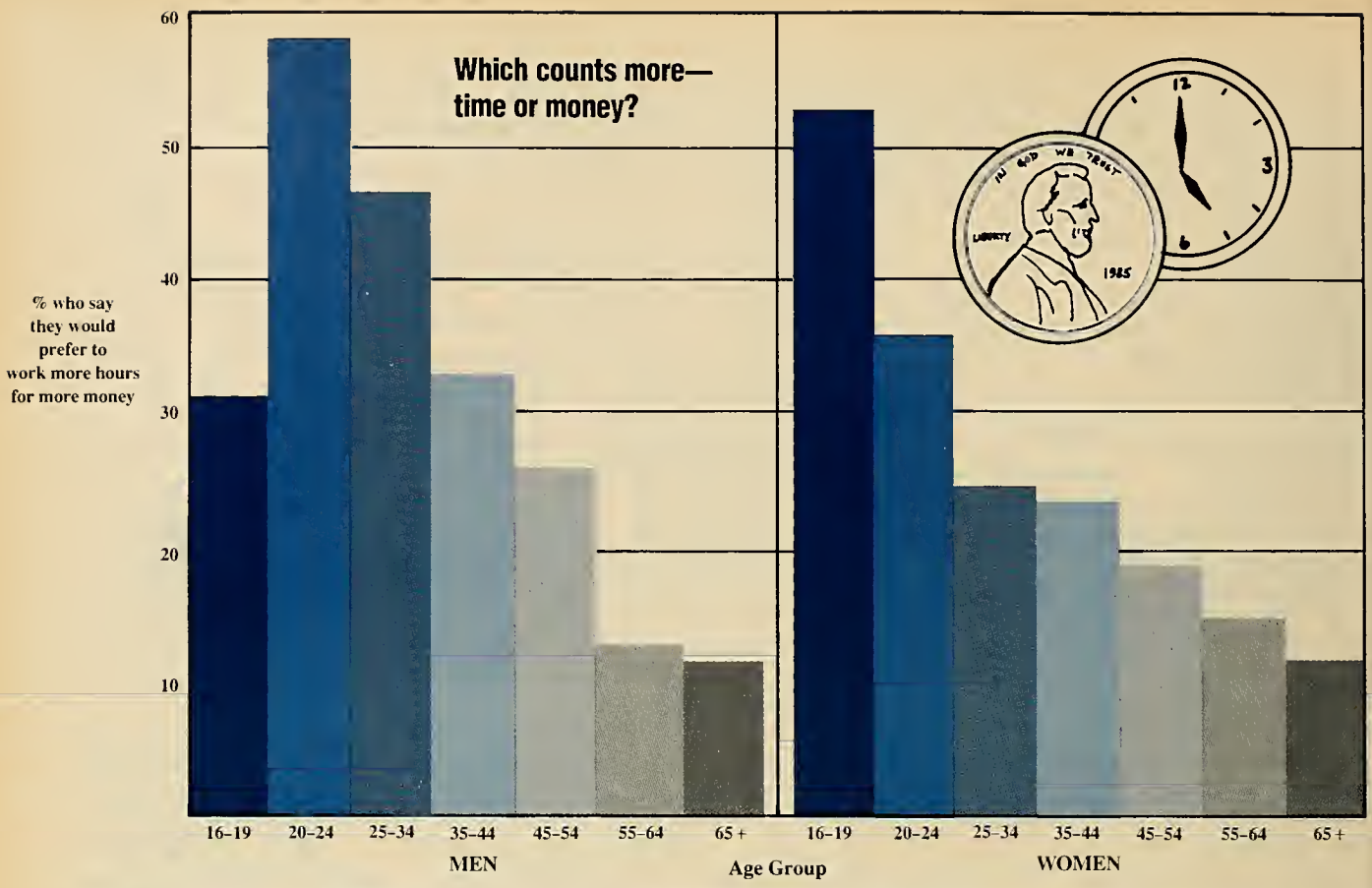
"ONE THING OUR SOCIETY has not dealt with very well is that we've not really addressed the issues of work and family coming together," says Carol Auster, assistant professor of sociology at Franklin and Marshall College (F&M). "We're still where we were 20 years ago, although there have been some improvements, like flextime and day care on site."

America has a long history of manipulating the female work force by using the competing demands of the economy and the home, Auster notes. During World War II, "the federal government was saying, 'Please come to work!' and making films on how to cook fast meals." When the men came home from the war and women were expected to leave the workforce, "they made films on how to make wonderful, five-hour meals. There were

Like the "organization man" of the 1950s, ambitious workers of today try to send a message that nothing comes before their job.

Who is likely to miss work for reasons other than injury or illness?





Helpful Hints for Working at Home When the House Talks Back

To set your own hours, to have no visible supervisor, to commute only a few steps to the office—to work at home and be paid for it—seems like the perfect compromise between job and family.

But it is the much-envied flexibility of home-based work that can create conflict and anxiety for those who do it. Kathleen Christiansen, director of the Project on Home-Based Work at City University of New York, says the biggest challenge such workers face is putting time and space between being at work and off work.

"When you shut the front door as you leave for work in the morning, you symbolically and literally put a boundary between self and personal life," Christiansen says. The office is a place designed for work; the home teems with distractions.

"Home has its own language, which seems to afflict more women than men. As one woman said to me, 'If you work in an office and you go to get a drink of water, the water cooler doesn't say, 'Defrost me.'"

Even more compelling than the pleas of appliances can be the demands of children, friends, or pets, especially since one of the main attractions of home work is the opportunity to take care of children or elderly relatives. People who would avoid taking personal calls at the office find it difficult to ignore a ringing doorbell or a four-year-old's pleas.

Christiansen says that home workers often devise going-to-work rituals to reinforce the difference between being on the job and in the home:

"People would walk out the front door, go around the block, and come home. Many would turn on the answering machine promptly at 5 p.m. and go out and walk the dog. A story I've heard from several sources is about a man who worked as a broker who had a tape recording of the market opening and closing."

Creating time limits can also help home workers avoid the feeling that whenever they're not attending to the family, they should be sitting in front of the typewriter. Christiansen reports a high rate of burnout, especially among people operating businesses out of the home. An office worker who wakes up at 3 a.m., inspired or driven to finish a job, can't hop out of bed and rush to the office. But the home-based worker can—and often does.

Setting aside a work-only space in the home is essential. The bedroom may be the most comfortable place to work at the computer, but the bookshelves, TV set, and unironed laundry can be distracting, while the computer can become a haunting, around-the-clock reminder of work—especially at bedtime. The ideal home work place has a separate entrance from the rest of the home and contains things that symbolize work: a file cabinet, a desk set, a desk calendar.

Christiansen explains that this separate entrance may be a necessary luxury:

"Particularly when you have a young child, the door to the office is not a sufficient boundary. The child doesn't understand that Mommy has to work now." She notes that men working at home traditionally have had wives to act as

films showing how children were running around on the streets and getting into trouble because there was no one to watch them."

Women have always worked in the home, but their financial contribution in the 20th century began after the enactment of child labor laws. "In working class families, traditionally the father and the children worked," says Lois Scharf, adjunct associate professor of history at Case Western Reserve University (CWRU). "By the 1920s, there were signs of reduction in child labor and of wives entering the work force, in a sense replacing their children.

"In the '20s and '30s, with the increase of working wives, you began to get the sense that families wanted more money as the consumer society developed. In some ways, the two-income family today is really revolutionary, as much as anything is. Middle class families really can't attain their desired standard of living on one income."

The need to work and the shortage of day care have forced women in particular to find ingenious ways to make extra money and, when possible, decide when and where they will work. Moonlighting and multiple job-holding, for instance, are on the rise; the BLS reported that in 1985, 2.2 million women held more than one job, an increase of 40 percent since 1980. Kathleen Christiansen, professor of organizational behavior at City University of New York and director of its Project on Home-Based Work, surveyed 14,000 women through a national women's magazine, and interviewed many personally. Based on her research, she cites the need for women to hold more than one job.

"You've got to take a look at the median income," she says. "It's going to take a job and a half to earn what a man makes in one job. In most jobs, there are still rigid 8-to-5 or 9-to-5 schedules. A lot of the women I've interviewed take multiple jobs: one for benefits, another for money or creativity."

Another popular alternative is home-based work, which ranges in scope from a few hours of clerical work or telemarketing to full-scale businesses. Based on her study, Christiansen now concludes: "Home-based work may still be the best of not very good alternatives for providing for work and family." Companies out to recruit home workers often show women sitting at computers while their young children play contentedly—and silently—behind. In reality, of course, the children demand attention and the work gets put off until after bedtime or before breakfast, she notes. "To me," Christiansen says, "'flexibility' is a horrible euphemism for exhaustion."

As it happens, home-based and part-time jobs fit conveniently into the mold of corporate restructuring, but not necessarily to women's advantage. "There's a potentially dangerous intersection between the corporate need to downsize and the fact that women are increasingly looking for flexibility. To go out on their own offers them more in the short term. But I think as corporations are professionally restructuring, these jobs are being changed to part time," Christiansen explains.

So, she warns, women who choose non-salaried work, planning to re-enter the full-time force later, may find when they return that such jobs are no longer available. The positions will belong instead to the unencumbered few who Christiansen says, based on current seniority,

As corporations scale down, women now stopping out of full-time work may later have little choice but part-time jobs.

"gatekeepers," screening interruptions. As it is, one-third of the women in Christiansen's study used some form of child care even while working full time at home.

While home workers are spared the pressures of commuting or the rigid time constraints of the office, they often do feel lonely and isolated, with no co-workers to talk to or lunch with. Such feelings can put them in conflict with a partner who works outside the home.

"The problem is that they're on entirely different rhythms," Christiansen says. "The spouse who works outside wants to come home and collapse. The spouse that has been at home wants to get out. They've worked alone all day; they want to talk."

Finding a middle ground that satisfies both is a matter of bargaining. Constance Pilla Uliano, a Franklin and Marshall graduate who is a part-time teacher and free-lance editor, has an informal arrangement with her husband, who works long hours managing his own construction business. She does grocery shopping on week nights, leaving the care of the two small children to her husband once he is comfortably settled in front of the VCR. "It's true you have to negotiate," she says. "For instance, I'll say to him, 'I'm not cooking on Wednesday and Thursday nights because I have a long day at school.'"

Between balancing work and family and facing the condescension of those who don't believe their jobs are "real," it's no wonder that home workers often feel tired, stressed, and frustrated. But Christiansen admires them for their ability to turn a tangle of conflicting needs into a functional way of life: "I think the remarkable stories are about those who really do well."

"will be older, white, middle-class men." F&M's Carol Auster notes that the promotions-for-loyalty exchange still favors men because "organizations use male indicators for what they consider loyalty. They assume that there's someone at home taking care of things. Men are still less likely to say, 'I've got to stay home because I've got a sick kid.' "

Since circumstances favor men in management positions, women who have left the work force may have to settle for a part-time role. "The peripheral workers are going to be women, older workers, and teenagers," Christiansen says. "Older workers will be more in demand because of their experience."

For those left outside, work can still be profitable and satisfying, even more so than a salaried job, as in the case of small-business owners. But the potential exists to create an exploited class that works as hard, and in constraints as rigid, as salaried workers, but reaps few of the rewards. Companies often do not pay for benefits, vacations, or sick leave for part-time workers, but according to Christiansen, "They're likely to get at least three-quarters of a day's work out of each person sharing a job."

Contract workers, who make up the majority of home clerical workers, are particularly vulnerable to abuses of their time. In theory, a woman who does computer data entry for an insurance company may receive no company benefits and a flat rate for the number of forms she completes, but can set her own hours and "vacations." In practice, she may be subjected to a heavy work load and strict time limits, but may fear to complain because she needs the money.

The system reminds Lois Scharf of the "piece work" done by women at the beginning of the century: "The truth of the matter is, it has always been a terribly exploitative enterprise. This is the 1980 version of the 1910 immigrant family making artificial flowers or finishing up buttonholes in tenement apartments."

Regardless of its hazards, Christiansen sees non-salaried work as an overall plus for women: "I think companies are motivated by their own bottom-line interests. It just happens that the supply side is very willing to take part-time jobs. The most beneficial thing is that it exists as a choice."

The rise and fall of the 40-hour week

IN SPITE OF the leakage between work and home time—taking an hour off for a child's dentist appointment, finishing a report at the dining-room table—the five-day, 40-hour week rivals perhaps only the weather as a topic of universal interest. From Monday morning cartoons to Friday afternoon resort-bound traffic jams, city culture reflects a way of life that is only half a century old. In 1938, the Fair Labor Standards Act instituted a 40-hour week and set the minimum wage at 25 cents.

"My sense is that the five-day, 40-hour week is really a product of the Depression mentality and the need to spread the jobs around," CWRU's Lois Scharf says. But the drive for a shortened week dated almost to the beginning of the 19th-century industrial revolution and the extraordinary changes it brought about in attitudes toward work itself.

In agricultural society, Scharf says, "work was task-oriented. You did what you had to do as long as you had to; then, you could do nothing." Early industry followed the same cycle: "When the first New England mill girls went into factories, the work day and the work week were much like they had been traditionally. You worked from sunup to sundown, longer in the summer and shorter in the winter."

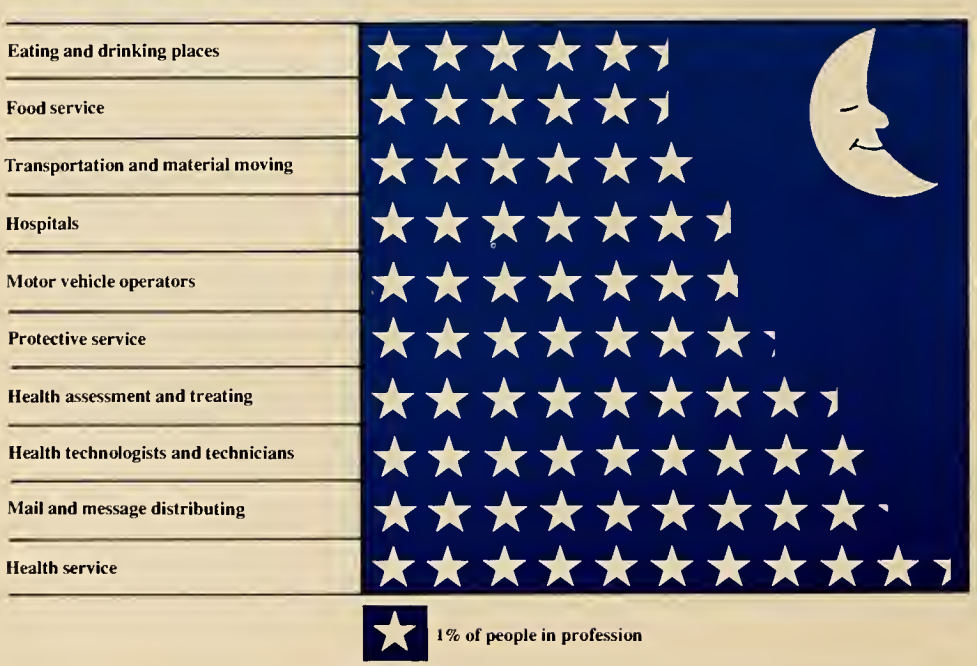
The advent of assembly-line machines with interrelated functions brought the need to work set hours at a steady pace. "A new sense of work discipline developed, and it became a discipline that was time-oriented," Scharf says.

The emphasis on time rather than on intensity of labor was reflected in what American workers wanted—and what unions tried to get for them. "Up until the 1950s, the U.S. had taken half of its increase in production in real income and half in the form of a reduced work week," says Wharton's Ross Webber. "For a while in the 1950s, unions still pushed for a reduction of the work week, and we certainly got solidification of the five-day work week. Since that time, the formal work week has stayed sort of stable, partially because the rate of increase of production has slowed down. But what was going on in reality was that the work week for managers and professional people started to increase through the '60s and '70s."

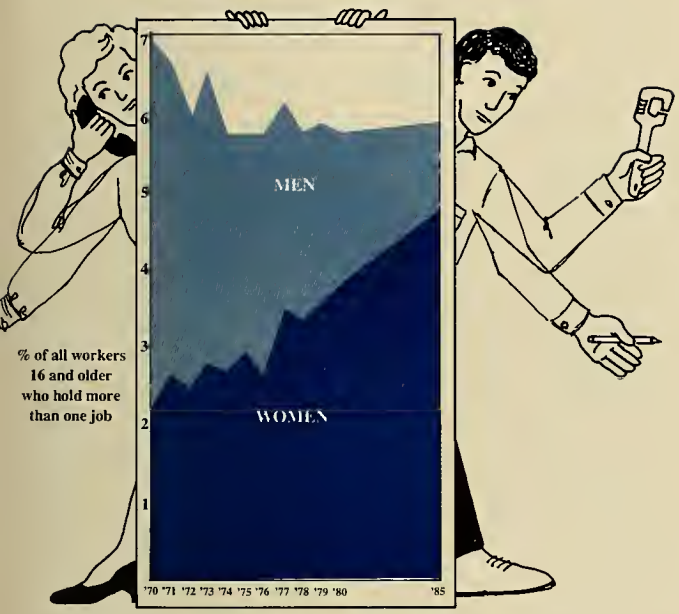
Webber points out that the increase in the amount of hours people spend on work conflicted with a new attitude about work's importance: "You had this phenomenon of recognition, a residue of '60s counterculture, which argued that life shouldn't be completely subservient to work."

Trying to accommodate the

Who is most likely to work the night shift?



Multiple jobholding is on the rise for women



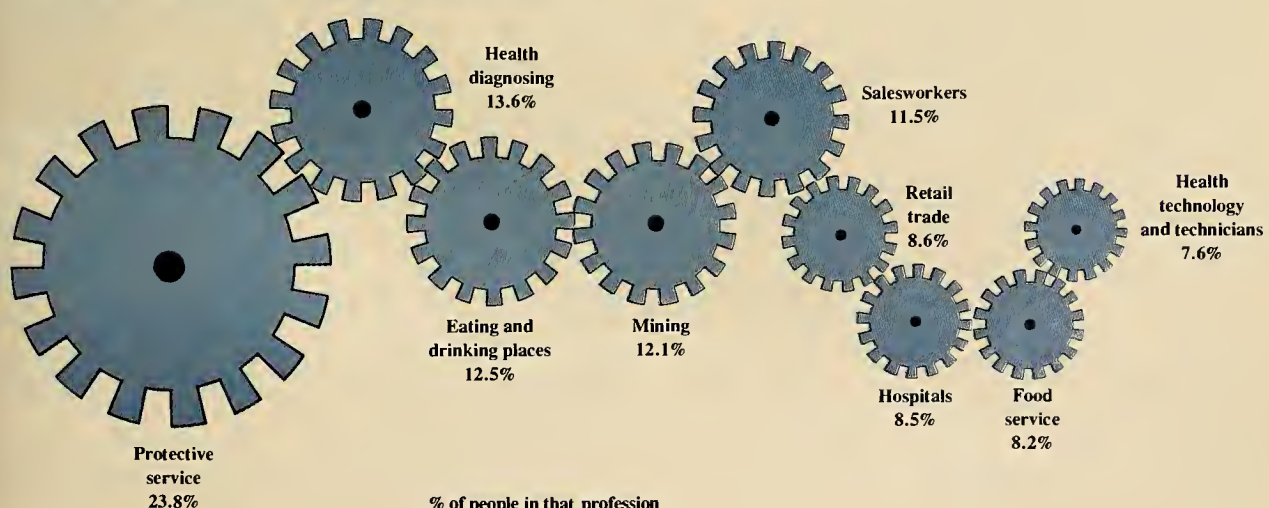
desire for a less regimented and demanding schedule, business introduced innovations like flextime (in which employees can choose from a range of starting and ending times); the four-day, 10-hour work week; and work "sabbaticals." These ventures were part of a general move to make the work place more relaxed and comfortable. A focus of this drive was the care and feeding of people whose responsibilities consisted of more thinking than doing. The almost legendary pampering of research and development whizzes in California's Silicon Valley stemmed from the realization that "creative work can't be turned on and off by the clock," Webber says. High-tech factories began to leave the doors unlocked so that people's offices would be available in the event of sudden inspiration.

The new machine age brought an attitude toward work reminiscent of the age before machines, when the work day conformed to the tasks that had to be done. But the idea of more flexibility also appealed strongly to a growing group in the labor force that was feeling the constraints of time. "Flextime is rooted in the idea of creativity of professional workers, but was also very hospitable to what the feminist movement was trying to achieve," says Webber.

The political drive to promote flextime has been most successful in government employment. In 1985, the Bureau of Labor Statistics found that 20 percent of federal employees now have the option of more flexible hours. Studies show no decrease in productivity, modest gains in work satisfaction, and fewer sick days taken. But despite the widespread attention to and strong appeal of flextime, the same study showed that only 12 percent of workers at large had flexible schedules

Since the advent of factories—and the time clock—employees have fought for a shorter week.

Who is most likely to work rotating shifts?



Is It Your Fault You Work Late?

Pressure to prove oneself to the company is responsible for a lot of late nights, but often employees must share the blame. Although books like *The One-Minute Manager* have drawn attention to personal time management, there are many otherwise successful people who can't set goals, limit interruptions, and arrange tasks efficiently. Though they feel overworked, their real problem may be that they are underorganized.

Dr. Helen Vassallo of Worcester Polytechnic Institute, who has led executive seminars on organizing time, believes that a "system" for management is less important than having a clear sense of what needs to be done, when, and how. "I think there's more return on time management by not only doing things right, but by doing the right thing," she says. "If you set your goals properly, you'll do a better job of time management." She compares setting short-term goals to scuba diving: "Every time you come up, you've got to take a sighting. It's important to constantly set goals in small enough pieces that you can accomplish them."

Dan Rees, professor of sociology at Western Maryland College and a consultant to small businesses, believes interruptions are the leading time-waster for managers, a sign they may not trust employees to handle a problem alone. "Managers don't confront employees to handle it themselves," he says. "They make people too dependent. I find with many that they say, 'I come in on weekends and stay after work so that I don't get interrupted.'"

Arranging tasks to fit the natural rhythm of the day can help people be more productive. "Time management is looking at what type of person you are," says Robert Stokes of Villanova University. "A lot of it depends on your peak hours." If you're at your most alert in the morning, "pick the activities that are mentally draining and do them early, then save the other activities for later. If you are a writer who also has to talk to clients, then maybe you should do the heavy-duty writing in the morning."

Making the most of work time is especially important since productivity begins to decline after a certain number of hours on the job. How long people can work before they start to feel the effects depends on the interest level of the job and how they respond to pressure.

"People can't work well after six hours," says Dan Rees. "After that, decision-makers as well as assembly-line workers fall off in productivity. A stimulating and exciting job allows them to work longer hours, but decision-making ability does fall off."

When people work long hours to the detriment of their health or productivity, companies must take action, Rees says, even if it means ordering the worker to stay away one Friday every month, or on weekends. "Believe it or not, they'll get upset, even if they're getting paid for that time," he says.

As long as companies are demanding more work, he feels, they should offer more than just the occasional workshop to help people control their time: "What I find is that the effort is too piecemeal. Really bright people go into management, but the demands are so great that they can't keep up. Companies should definitely get people to balance work and personal life."

available to them. One reason for the slow take-off may be that jobs themselves have become more demanding than ever before.

From daytime to work time to no time

BETWEEN THE AVAILABILITY of a part-time work force and the apparent readiness of full-timers to work as long and hard as necessary to advance, companies seem well equipped to deal with the transformation of the economy. Given this convenient situation, what motivation is there for companies to offer flextime or other alternative schedules?

The answer—fortunately for workers—is that the quality of work is as important as the quantity. The last decade has seen a gradual awakening to the idea that the identity of employees extends beyond work hours, and that for them to be content—and therefore productive—companies must pay attention to all aspects of their lives.

Some of the new perks—like providing free sandwiches so that lunch breaks won't stretch to an hour and a half—have obvious payoffs in time saved on the job. But others, like on-site health clubs, child care, and employee assistance programs, aim at easing the pressures of personal life. "I think employee counseling can really help," says Villanova's Robert Stokes. "Stress is really a matter of how we react to a particular situation."

Today, stress and time are practically synonymous. Together with longer work hours, the growth of international business and such innovations as electronic communications have eroded evenings and weekends.

Victims of the lengthening day include not only executives but the "blue collar" service workers—hair dressers, dry cleaners, supermarket clerks—whose hours have been extended to accommodate their clients. The row of local businesses that locks up promptly at 6 p.m. has been exchanged for the permanent day of the shopping mall. In large cities especially, concepts like "after work" and "Sunday afternoon" have little meaning.

"I'm struck, particularly in New York, by the fact that at certain times of night, even if it's very late, you can be in a restaurant and it's full of people," says Columbia's Ellen Auster. "If it weren't dark outside, you'd have no idea it wasn't noon. There's no official off time anymore. It's such a contrast to some other cultures. When I was in Italy, whole cities closed down from 1 to 3."

Perhaps nothing attests more strongly to the preciousness of free time than how much people will pay to get it. "One of the biggest rewards people give themselves now is time," says Stokes. "People buy time by getting a babysitter or someone to cut the grass."

No amount of money will buy the time most people—especially if they have children—now need. As companies adjust to the new constraints of the marketplace, individuals are finding it hard to accept that what they do to balance their lives is both heroic and insufficient.

"The big message," says Ellen Auster, "is that you can't have it all at the same time. Something gets hurt. Over a lifetime you may have it all, but at different stages, your marriage, your career, your children will suffer." For those who have yet to realize this, time is running out.

Julia Ridgely works an 8:30-to-5 schedule as assistant editor of the Alumni Magazine Consortium.

Photograph by Bill Snead, *The Washington Post*, courtesy of Maryland Transportation Authority

Painters prolong the life of Maryland's Chesapeake Bay Bridge. One span is closed until May for deck repairs.

Where the Rubber Meets the Road

Today's civil engineers follow in the tread of giants. But the path to progress has its share of accidents, detours, and crossroads.

By Donna Shoemaker

A Roman aqueduct or an Aztec temple, a Stonehenge or a Great Wall, an Egyptian pyramid or a Colossus of Rhodes: These are solid legacies of civilizations past. All were engineered even before the profession had a name, before the artistry had been fused with science.

Modern manifestations of civil engineering are the industrial counterparts of those earlier edifices, the colossal commonplaces of our age: skyscrapers and supertankers, airports and interstates. Most people notice the flashier aspects of engineering, like the restoration of the Statue of Liberty (which earned this year's highest award from the American Society of Civil Engineers).

But it is in the more mundane areas that engineering ingenuity may have raised its torch the highest by vastly improving the quality of daily life. Consider, for instance, facilities for generating electrical power, treating sewage, and purifying water. "The contributions of civil engineering to improving public health have probably exceeded those of medicine," says Fred Moses. There is no hint of hyperbole in the voice of the Case Western Reserve University (CWRU) professor of civil engineering. Engineers know that their projects will be used the day after they are finished, he adds.

In spite of such accomplishments, in a society already highly industrialized, civil engineers seem to have less status today than do their counterparts in the "hot" fields of electrical or computer engineering. They earn less money (although the salary gap is narrowing). They tend to get attention only when

AP/Wide World Photos (all)

What goes up has been known to come down. Structural trouble spots during the last decade included (left to right) the windows that fell out of Boston's John Hancock tower in 1985; the collapse this year of an unfinished high-rise apartment in Bridgeport, Conn.; the cave-in of the Rosemont Horizon Stadium roof in Illinois in 1979 (top right); and the fallen roof of the Washington Bible School under construction in 1978 in Prince George's County, Md.

their projects fail. And they are accused of upsetting the ecological balance. All of this has dimmed their light.

In the United States, "our infrastructure is in place, and we tend to take it for granted. Laymen get the impression that the breakthroughs aren't there. Only when it doesn't work do we notice and get annoyed. But that's misrepresenting it," states Ross B. Corotis, chair of The Johns Hopkins University civil engineering department.

The United States in the last 100 years or so experienced an engineering heyday. With the growth of cities and suburbs, buildings towered above ground and a technological maze of pipes, sewers, and subways spread out below it. Showstopping spans like the Brooklyn Bridge (1883), the Golden Gate Bridge (1937), and the Chesapeake Bay Bridge (1952) linked thriving areas with more isolated ones. "People sometimes make the argument that anything man builds diminishes the effect of a great landscape," says author David McCullough. "But I think at heart that is a dishonest argument." He believes a bridge like the Golden Gate "makes a magnificent place even greater," for it gives both scale and drama to the landscape.

The time between the Civil War and World War I was engineering's greatest epoch, says McCullough; he chronicled two of its milestones in *A Great Bridge* (the Brooklyn) and in *The Path Between the Seas* (the Panama Canal). In that era, "it was as if these engineers were taking part in one of the great crusades, and they knew it. The culture in which they lived believed in their work, and what they were doing was heroic," he says, his resonant voice reflecting the excitement of those days.

Engineering flourished as well in the next few decades. Such massive projects as the Tennessee Valley Authority, launched by Franklin D. Roosevelt in 1933, reshaped the region's landscape and economy by creating 16 new hydroelectric dams and modifying five more. The great era of public works before World War II produced the big projects—the Hoover dams—that "captured the

public's imagination," notes Richard H. Gallagher, a civil engineer and provost and vice president for academic affairs of Worcester Polytechnic Institute (WPI).

The late 1930s, some would say, were "a time of buying our way out of the Depression—of getting the farmer out of the mud and onto the highway network," notes Villanova graduate Stephen Lester, a district engineer for the most populous region of PennDOT (the Pennsylvania Department of Transportation).

During this bustling age, what virtually entered American folklore was the image of the engineer as the "lone surveyor in boots and mackinaw, the wizard inventor in his workshop, and the master of the industrial dynamo," as a National Research Council report put it in 1985.

That image still is a beacon in developing countries, where civil engineers are held in high respect. As agrarian societies undergo rapid modernization, these Third-World engineers find fertile frontiers. Some 200 cities worldwide now have populations exceeding one million, creating tremendous demands for sanitation facilities, roads, housing, buildings, mass transit, and power plants.

"The very brightest people from around the world want to be civil engineers, and they come to America because our training is premier," Corotis notes. Foreign nationals account for more than half of all engineering doctoral students in America.

Our nation's successors to the ancient world's builders and planners are seldom the heroes here anymore. Instead, people notice the highly public mistakes. Architects take the credit if a building is a success; civil engineers take the rap when one falls down. "When we fail, we do it in such a spectacular way," says Corotis, who heads the American Society of Civil Engineers' Committee on the Safety of Buildings. The collapse of the Kansas City Hyatt Regency walkway; of a Bridgeport, Conn., high-rise apartment building under construction; of an interstate bridge in Greenwich, Conn., are hard to keep under wraps.

On-site with Four in the Field

What has happened lately to the romance of the road, the rails, and the bridges? What's the terrain like for civil engineers today?

From the Philadelphia area, Stephen Lester oversees the design, maintenance, and construction program for 3,900 miles of highways with 2,900 bridges. His turf includes the recently refurbished Schuylkill Expressway (traveled by a half-million vehicles a day), and the last—and most controversial—sections of the mid-county expressway, inching its way through populous neighborhoods. Lester earned his bachelor's (1965) and master's (1969) in civil engineering at Villanova University, and since June has been the district engineer in charge of PennDOT's five-county Philadelphia area.

"The need for highways will be with us forever—it's not a fad field," he notes. He is quite conscious of how much thought goes into designing roadways, making them safer for drivers and for the crews repairing them. For example, transportation engineers seek ways to help drivers avoid the "dilemma zone" right before traffic lights: those critical few feet in which you have to decide whether to run the yellow or screech to a stop. (Sensors that can detect gaps in the lines of vehicles will improve sequencing of stoplights.) Lester is looking at alternatives to using salt on icy roads to avoid its corrosive effects. He is interested in improved skid-resistant coatings for bridges. He wants "to get new technology down to the municipalities."

Pennsylvania in 1982 dedicated $1.4 billion to rebuilding its deteriorating bridges, and added to that $1.6 billion in 1986 (the state has some 23,500 bridges over 20 feet in length). The need is "absolutely essential," Lester believes. "We're routinely inspecting every one of our bridges. Because of the billion-dollar program, we're able to go ahead and get construction done ahead of schedule."

Extending roads through neighborhoods requires care, says Lester.

Peter Howard

In upstate New York, Tony Leketa heads out every day in his four-wheel-drive vehicle to an 11-square-mile area of rolling farmland. There, 2,300 workers are building a new Army base. Three years ago, Fort Drum was only an idea, but one that swiftly got the Army's green light. Four years and some $1.3 billion from now, the base will be getting its finishing touches. "The speed with which this whole thing is happening is historic," explains Leketa.

Fort Drum will house 10,000 soldiers (6,000 of them move in this November). Thirty-five miles of new roads will lead them to all-new facilities: barracks, homes, schools, a day-care center, a fire station, a heating plant, equipment and supply shops, maintenance areas, a skills development center, athletic fields, a bowling alley, and, of course, a shopping mall. "A new shopping center in the metro Washington, D.C., area would be no big deal," says Leketa, "but there's nothing like that here." An area engineer with the Army Corps of Engineers, Leketa supervises a staff of 30. He earned his civil engineering degree from Worcester Polytechnic Institute in 1969.

The construction of Fort Drum includes the single largest Army Corps of Engineers contract awarded since World War II, and the Corps is the world's largest construction organization. The adjacent town of Watertown, which will see its population double as a result, "was a little reluctant to accept that it was going to be the new Fort Drum. We were cutting roads through and people still didn't believe it."

Often accused in the past of bulldozing environmental concerns, the Corps has had to pay strict attention to the fact that this project lies just 25 miles from Lake Ontario. "We were very concerned about sediment control and the environmental impact," says Leketa. Miles of scrub had to be disposed of through controlled burning. Dozens of abandoned farms on the site came under scrutiny from the Corps and from state preservationists.

Building Fort Drum brings into play many specialties in the civil-engineering catalog: soil and site analysis, wind engineering, structural reliability, hydraulics, fluid dynamics, urban planning, surveying, transportation, water resources, construction, pipelines, and mechanics.

For Leketa, gazing over the site, "there's a tremendous sense of accomplishment. There's not much opportunity to build something from scratch, right out of the ground. My idea of hell is sitting at a desk doing design calculations. If I couldn't get out in my four-wheel-drive vehicle and see what's out there, it would drive me crazy."

Based in Cleveland, Gregory P. Chacos is a detective called in to find out what went wrong and why, so that those at fault will know "whether to fight, run, or settle out of court." He eschews the more fashionable term of forensic engineer in favor of calling himself a structural consultant. After earning a bachelor's (1951) and master's (1958) in civil engineer-

Plan courtesy Army Corps of Engineers

Fort Drum's master plan shows the massive scope of the Army base rising from the farms of upstate New York.

ing from Case Institute of Technology (part of Case Western Reserve University), for 18 years Chacos headed his own engineering firm, providing design services to architects, contractors, and owners.

Chacos is all in favor of advanced technology and used computers in design 15 years ago. But, he says, "to be a bit flip, a lot of the increases in current technology end up giving me more work. I see difficulties in projects that take stuff right off the computer printout and put it into the building design—the more automated the design becomes, the more I see funny things happening. Projects get horrendously complicated, and needlessly so."

Consulting takes him to New Jersey, West Virginia, Oregon, Washington, D.C., and often into the courtroom to testify. He was called to Detroit to consult on repairing the new 2.9-mile "People Mover" elevated rail system, which suffered cracked guideway girders and overran its $137.5 million budget by more than $60 million. In Motown, a city more reluctant than most to give up its cars, the People Mover was dubbed "the rich people's roller coaster."

His style of consulting, says the affable engineer, is best done alone and on-site. "If I can't see it, smell it, and feel it, I can't get the proper approach to the problem."

Around Worcester, Mass., "the climate has been ripe for development, and it's come," says Carl Koontz. He monitors all building permits for the city's 50,000 structures.

Like Chacos, he's wary of the revolution in computerized design, concerned that, to reduce costs, engineers are "designing tighter and tighter to meet acceptable factors of safety." He emphasizes that "building codes are specifically built on experience collected in the past. When people start extrapolating past that experience, when engineers try to creep up on that factor of safety, the lessons learned are costly." A professor emeritus of civil engineering who taught at Worcester Polytechnic Institute for 35 years, Koontz last year took up this second career as Worcester's commissioner of buildings and code inspections.

Quite typical of New England's older industrial areas, in this city of 175,000 people, through the years, the main water and sewer pipes have become clogged, covered with scale, and a breeding ground for bacteria. With any decayed system in need of replacement, "a whole host of problems develops. How they'll be conquered only time will tell." Boston—only 40 miles away—faces a $3 billion job of replacing its outdated sewers and cleaning up its harbor. Koontz sees these seemingly more ordinary problems—corrosion, wear and tear, repairing of hard-to-access structures, conserving energy vs. preventing indoor pollution—as being far more worthy of research than are some of the profession's enticing new options.

The public "hears about the monsters," John Loss points out. Through a databank called the Architecture and Engineering Performance Information Center (AEPIC) at the University of Maryland, the architecture professor keeps track of basic information on 58,000 buildings and public-works structures, some dating back to 19th-century railroad days and even earlier. Graduate students are coding far more detailed information on 5,000 cases from the past 20 to 30 years from state and federal appellate courts, forensic engineering files, and insurance claims. By the end of next year, AEPIC will have 10,000 detailed cases, and thus can give the industry (and the lawyers who use AEPIC heavily) "a pretty good idea of what's happening" in terms of deaths and injuries, cost overruns, delays, and structural failures.

Leafing through his printouts, Loss pulls out data on the new cases coded so far: "The percentage of problems is running highest for sewage treatment plants, highways, pipelines, and bridges." Metals become fatigued; cracks develop. When steel embedded in concrete corrodes, a bridge pile gives way. Highways built to bear truck loads of 20,000 lbs. show the strain of tractor-trailers weighing 90,000 lbs.

Loss's figures show that in sewage treatment plants, design errors account for 40 percent of all failures, with the major defects to be found in mechanical equipment. But it is not always easy to determine how such problems developed. Maintenance may have been faulty or a plant may have had soil stability problems. "Sewage treatment plants are going into the worst environment—one that no one else wants. They're much less predictable sites to be working on," Loss says.

Through AEPIC, he explains, "one of the things I'm attempting to do is to get a better handle on the problems. There's been a lot of misinformation in the past, and we haven't had much back-up data."

Not all failures are spectacular. Routine wear and tear takes an enormous toll. By the mid-1980s, civil engineering had come to be identified with propping up America's crumbling infrastructure—at a staggering projected cost of $1 trillion. Students then, who might have entered the specialty, instead detoured around a career

they perceived to be drearily shackled to refilling the nation's potholes, replacing its rail tracks, and resurfacing its bridges, notes James O'Shaughnessy, head of civil engineering at WPI. But the students have been coming back—and the field has been attracting women as well. One-fifth of civil engineering undergraduates at Villanova and WPI are women, about the national average.

Fred Moses at CWRU points out, "At first glance, it appears less glamorous to be involved in maintaining existing systems, but in the long run, the jobs are there and it is socially useful." Dick Gallagher at WPI—whose daughter and four sons all became civil or materials-science engineers—sees students now choosing civil engineering because of the significant jobs created by repairing that infrastructure. Villanova's graduating civil engineers can select from four or five good offers, says Jim Schuster, a professor of civil engineering who has taught there for 28 years.

"Enlivened and enlightened teachers," adds David McCullough, can inspire in students a sense that this is a profession that "walks in the tread of giants." Good teachers can encourage future engineers to avoid what he calls the "tunnel vision" of narrow specializations with no humanistic, civilizing perspective. They can lead students to become the problem-solvers for the "very large, very important, very critical problems" that lie ahead. "There has never been a greater opportunity for talent," the author believes. "So much of what we built in the past has to be replaced and rethought."

Civilizing a Nation in its Youth

For lack of a homegrown crop, America of the late 1700s imported civil engineers. To taper off that dependence on European expertise, Thomas Jefferson, in 1802, established West Point Academy, hoping it would develop an American corps of civil engineers, and it did.

It was an Englishman who had to show the Yankees how to build a turnpike when the first major one to be constructed in the United States (1792–94) washed out in the rain and sent horses stumbling. Pennsylvania's Lancaster Pike, a 66-foot-wide earth-and-pounded-stone road, joined its namesake (the largest inland city at that time) with the largest metropolis, the port of Philadelphia, 62 miles away.

By the mid-1800s, civil engineering had earned its spurs as a profession—the first engineering specialty to do so. The railroads had played a major part. In 1869 in Utah, the Golden Spike was pounded in to complete the first transcontinental railroad, thus linking the coasts and opening up the country as never before.

But even at the end of the 1800s, a city Philadelphia's size had no municipal waterworks, until the British-born Benjamin Henry Latrobe designed the first steam-powered water pumps. His project met with great skepticism, but he won over the doubtful when he and three friends opened the hydrants one night, fired up the wood-and-coal-fueled boiler, and showed how the Schuylkill River could be pumped to the people.

In early America, "a lot of barns sagged and buildings fell down, and gradually people adjusted and learned to build them better," Henry Muller explains. The former school principal, after retirement, turned his attention to his avocation, historic buildings. Muller supervises teams of masons, contractors, carpenters, historians, architects, and blacksmiths who are restoring private homes and churches in the central Maryland area.

When the roofs leak badly, the walls wobble, or the floors sink into the cellar, Muller calls in the civil engineers. In such cases, "we're afraid to do anything without someone who understands the forces involved," especially for structures built long before the days of stress-tested materials, notes the 1949 graduate of Western Maryland College.

Those buildings that stood the test of time did so because they were "basically overbuilt." Massive beams, thick masonry walls, and mortar lavishly applied held many a homestead together. Yet we may have lost some valuable construction techniques from the past, says Muller, among them mortise and pinion joints to fasten wood. "Those things have some usefulness—it's sad they're so labor intensive."

Who would not want a bridge to be safe, or a highway kept in good shape? But in many areas of engineering, the solutions aren't so clear. Recently, the perception has been growing that the civil engineer is a "morally ambiguous actor in society," noted another 1985 National Research Council report. The professionals once admired for harnessing nature and its resources are now seen as contributing to an "insupportable insult to the environment."

"Our activities are much more under scrutiny today—nuclear power plants, off-shore oil platforms—these take layers of review to provide adequate protection against errors," explains Fred Moses at CWRU. Adds Stephen Lester at PennDOT, "We have to be very conscious of the environmental problems. You can't go in and build a highway from point A to point B. You have to take into account water quality, residential neighborhoods, safety factors, blending in improvements with existing contours, and keeping in mind the priorities people have."

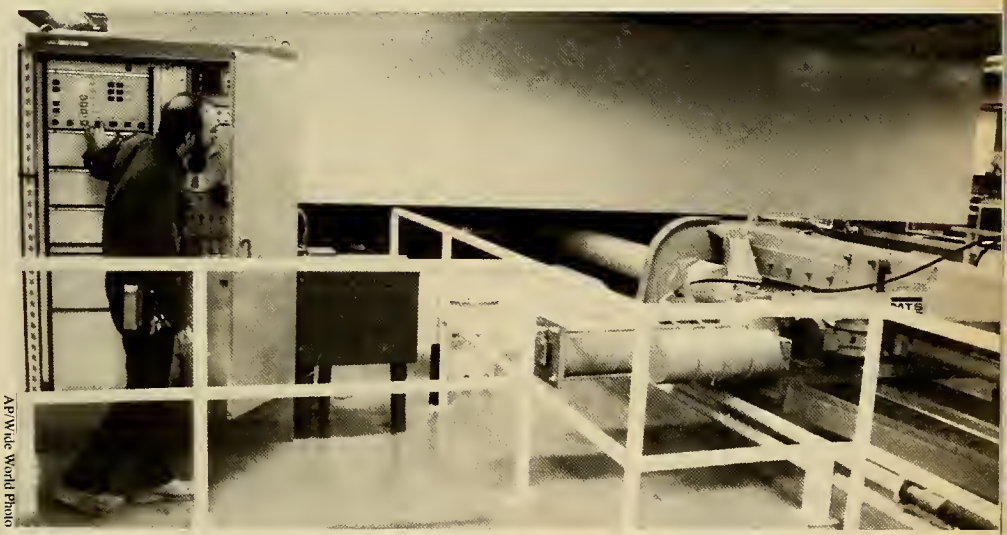
Engineers tend to look at the use of land "in terms of time periods that are human and historic," states geomorphologist Dorothy Merritts, "but geologists look at it in terms of millions of years." Geologists are especially concerned about the dangers of overusing resources and underestimating the long-term effects of large-scale projects. If not sited properly, construction and development can lead to landslides, erosion, the lowering of groundwater levels, and subsidence. That confluence of human land use and natural forces has produced a caldron of controversy.

In a city like Los Angeles, "they've paved everything solid" and lined the river and stream beds in concrete, adds Merritts, a Franklin and Marshall College assistant professor of geology. After heavy rains, deep gullies form, streams overrun their banks, and flooding can be severe. Los Angeles draws its water from as far away (some 500 miles) as the

Colorado River, also heavily tapped by Southwestern cities. As a result, lakes once plied by steamboats now are dry or too saline to be of much use, animal life has been displaced, and the variety of plant life reduced.

The 1970s environmental movement brought far more rigid requirements for assessing the impact of construction on swamps, marshes, and wetlands; on the food chain; on endangered species; on the pollution of water, land, and air; and on historical and archaeological sites. In less developed countries, such environmental effects are cause for concern as well. That Third-World dam generating power for city dwellers deprives the surrounding farm land of its fertilizing floods and thus may ruin the rural economy. Add to those challenges such emerging problems as the disposal and transportation of hazardous wastes, and it appears that "we keep finding new problems faster than we can alleviate the old ones," notes O'Shaughnessy at WPI.

"Many engineers recognize that they create an impact on the environment and on residential areas, and they have to design to mitigate that impact," says Jim Schuster at Villanova, who designed the walls used to reduce traffic noise following the widening of the Pennsylvania Turnpike. He talks about how design now "is for people and the environment and not the vehicle in the roadway." Years ago, highway signs were encased in concrete; now "breakaway" design reduces injuries when a car hits one head-on. The industry calls it "forgiving" design.



AP/Wide World Photo

In high winds, a 400-ton concrete block running up the middle of the Citicorp Center in New York can be moved to control the superskyscraper's sway.

There is a lot of talk—and action—in civil engineering about serving the public as well as a client. But the private sector is assuming a larger responsibility for what were once considered public works, for example, constructing a plant to transform trash into energy or connecting a freeway ramp directly to a shopping mall. IBM is picking up the multimillion-dollar tab for roads and a sewage treatment plant for its office in Southbury, Conn. Businesses know, says Villanova's Schuster, that with dampers on taxes and a drying up of federal funds, "they won't get it built in the near future unless *they* do it."

Building better, sturdier, safer, and more economically—amidst growing constraints—characterizes the challenge to civil engineering. Once built, facilities have to be maintained, says Schuster, so the design has to make it easy to get in there and paint, repair, or resurface. Some new materials have reduced the frequency of repairs: For instance, highway bridges constructed since the '60s use steel that resists atmospheric corrosion. As resources shrink, "we have to show how best to use them. You can't replace the nation's 250,000 bridges tomorrow. So what's the best strategy considering cost, safety, public liability? Often the repair requires much more planning, coordination, and thought than building the original structures," notes CWRU's Fred Moses, with whom Ohio officials consult frequently to evaluate the safety of the state's bridges.

To search for cracks, leaks, and flaws, engineers are employing nondestructive evaluation techniques, among them electromagnetic radiation and stress waves as well as ultrasonics, radar, infrared thermography, and other methods. "Civil engineering sounds very rudimentary because we use natural materials, steel, and concrete," explains Ross Corotis at Hopkins. But it's not. Composite materials behave in complicated ways, and the waves used in the tests may not always pinpoint the problem, he adds. But progress is being made. Researchers at Hopkins, for example, have been able to induce a magnetic field to find rust spots (called holidays) as small as a dime when the plastic coating on gas pipelines deteriorates and exposes the steel to oxygen.

Such technologies and methods—more so than the materials—are where the most promising recent developments have come from. Civil engineers have found numerous significant uses for computers, Corotis points out. Engineers can reduce corrosion by using a direct electrical current on steel anchor cables on bridges. They can deploy sophisticated remote sensing—which grew from the 19th-century French military's use of hot-air balloons for aerial photography—for mapping routes, conducting feasibility studies, and gathering data on terrains. A computational method WPI's Dick Gallagher pioneered in the 1950s at Bell Aircraft, called the finite element method, enables engineers to understand and design such complicated systems as Lunar Excursion Modules, computer components, and superskyscrapers by studying their smaller, discrete parts, then linking them back together to analyze the whole.

Civil engineers will continue to set their sights on such societal needs as constructing correctional facilities, improving overcrowded airports, and providing innovative ways to build under water. They are designing megastructures in which 10 to 20 stories function as a single structural unit, they are stretching suspension spans across several miles, and they are contributing to building ships and to the exploration of space. For professionals so closely tied to the earth's surface, civil engineers—far from feeling earthbound—see their future projects digging deeper, stretching wider, and soaring higher than ever before.

Donna Shoemaker is editor of the Alumni Magazine Consortium.

FRESHMAN DISORIENTATION
...a short-lived rite of fall

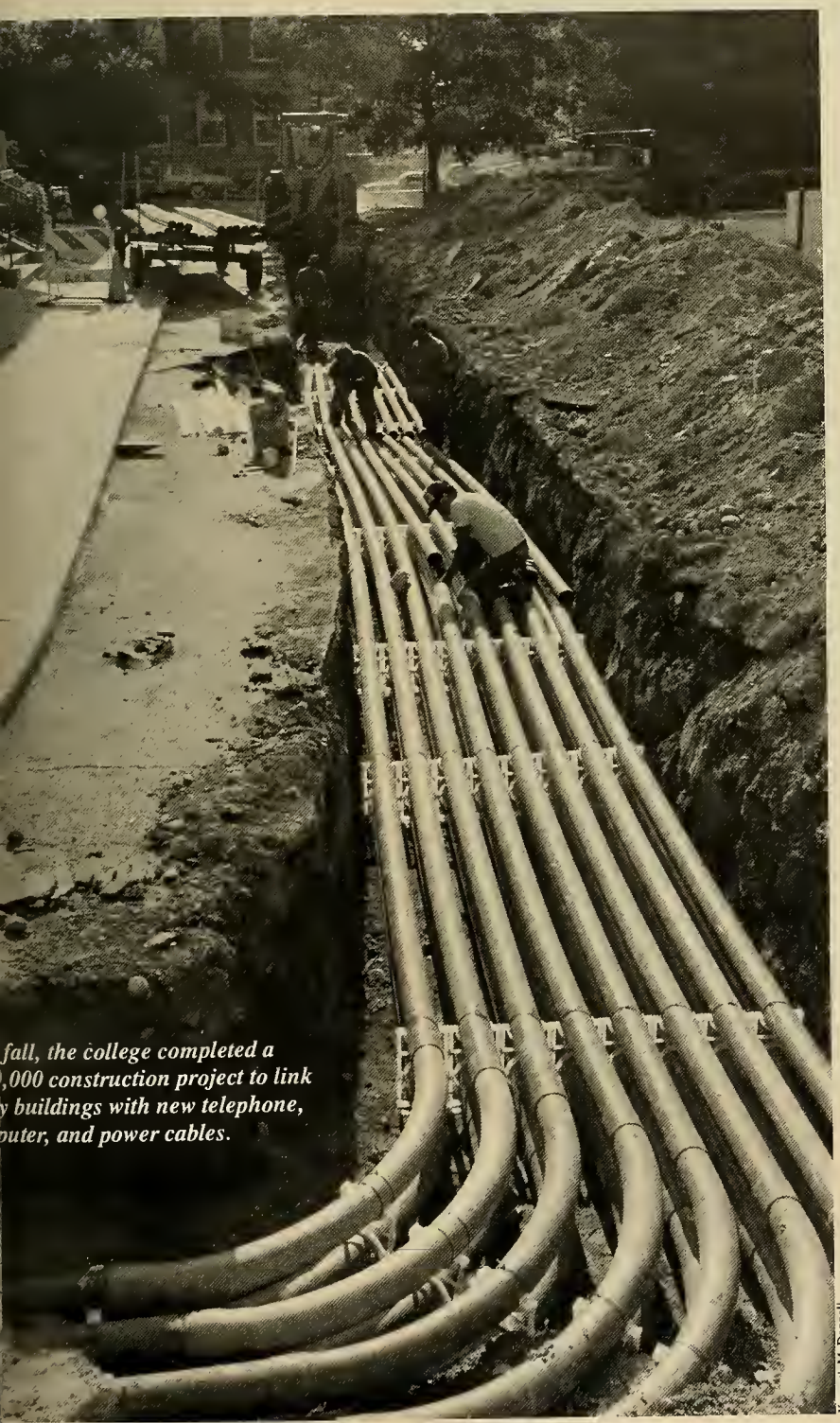
Sid Harris takes a fresh look at the first semester. The cartoonist's collected works include *Chicken Soup and Other Medical Matters*, *What's So Funny About Computers?*, and *Science Goes to the Dogs*.

Type A Freshman: Changed courses four times, took a job, organized a protest, quit the job, plans to take second semester abroad.

"I don't think Wally is going to last here. He found orientation week too difficult."

"You find out about starting salaries when you *finish* college—not when you *start* it."

Here, as at other universities, those who build and maintain physical resources have a unique perspective on the campus.



fall, the college completed a ,000 construction project to link y buildings with new telephone, outer, and power cables.

Kenneth McDonnell

Always Growing, Forever Changing

By Bonnie Gelbwasser

Take a walk through the campus and it won't be long before you encounter someone from the Department of Plant Services painting the trim in a hallway, reseeding a grassy area, tending to custodial chores, or restaining the intricately carved arches of Alden Memorial.

John E. Miller, vice president for physical plant, explains that the department's mission is to "maintain and operate facilities, plan for their major upkeep and repair, and work with architects and engineers to develop designs and construct new facilities. Former College Engineer Anthony Ruksnaitis '53 puts it another way: "The department is there for the safety, comfort, and convenience of the students, faculty, and staff."

The objectives of the $52.5-million *Campaign for Excellence* reflect the

To remain the pleasant place it is, the campus requires year-round maintenance and attention to detail.

Institute's commitment to the upkeep of the campus as a vital component of a WPI education. In addition to seeking funds for enhancing the undergraduate academic program and adding faculty and new programs, a goal of $19.6 million has been set for physical plant development.

The money, Miller explains, will be used for projects like the construction of Fuller Laboratories, which will house WPI's information sciences, the Computing Services Department, and a 400-seat lecture hall; completion of renovations to Salisbury Laboratories for programs in biomedical engineering, biology, and biotechnology; construction of an addition to Goddard Hall for the Chemical Engineering Department; renovation of the outdoor athletic facilities (completed in 1986); property acquisition to meet future needs for student residences and offices for support functions; and a continuation of the campus beautification program.

Once assigned to a few faculty members, operation and upkeep of the campus now rests in the hands of the 80-member Plant Services Department.

An additional $5 million in unrestricted funds is being raised to enable the college to take advantage of unforeseen opportunities and to limit the need for deferred maintenance (like long-term wear and tear on buildings, roof replacements, and masonry repairs).

Donald F. Berth '57, vice president for university relations and executive officer of the *Campaign,* admits that generating contributions for Plant Services can be difficult. "Tuition represents only 45 to 48 percent of the actual operating cost of the institution, which includes such items as heat, plumbing, and grass for the baseball diamond," he says. "It's tough

to raise money to replace rusted nails in slate roofs, to take out bricks that have cracked because of water penetration, to replace dead trees on the campus, to repair parking lots, pull the weeds, and paint the residence halls."

Ruksnaitis, who retired earlier this year, established the plant services department in 1956, when an active building and renovation program was under way. In the mid- to late 1950s, Morgan and Olin Halls were completed, along with an addition to Alumni Gymnasium; Boynton Hall, Washburn Shops North Wing, and Atwater Kent were renovated.

Before that, Ruksnaitis says, faculty members were assigned particular maintenance tasks. He recalls, for example, that A.J. Knight, professor of engineering, was charged with the upkeep of the buildings and grounds. William Locke of electrical engineering supervised electrical maintenance and distribution, and the power plant was under the direction of Prof. Robert Kolb of the mechanical engineering department.

These days, Miller says, his department maintains 1.1 million square feet of buildings, from academic and administration buildings to two gymnasiums and 62 acres of landscaped grounds, parking lots, and access ways. Miller, who has a bachelor's degree in mechanical engineering and a master's degree in management from Clarkson University in Potsdam, N.Y., came to WPI in 1982 from American Optical Co. in Southbridge, Mass. He says the work of Plant Services is divided into three categories: engineering, administration, and operations.

Engineering, he says, involves participation in the design and construction of new buildings. "There has been about $13 million in capital construction here at WPI in this five-year period," he says, "and we work annually on about 60 to 80 other projects in a wide range that includes deferred maintenance, smaller renovations, and the construction of new labs and reallocation of space."

WPI Locksmith Frank Mancini

Michael Carroll

Frank Mancini is a modern-day keeper of the keys. For the past dozen years, this quiet, dignified man has been responsible for keeping track of every key on campus—no small task, considering that there are locks on approximately 3,000 classrooms, laboratories, mechanical rooms (like elevator control and electrical rooms), offices, bathrooms, and dormitories.

A member of the Department of Plant Services, Mancini works closely with campus police and tradespeople to provide access and security for students and staff members. "My job is the most demanding classification on campus. Security here is *very* big," he says.

In his crisply pressed khaki uniform and visored cap, calmly fielding calls that come in one after another on his mobile telephone, Mancini explains that his job includes "repairing and replacing broken locks, resetting locks, and re-keying buildings or doors if keys are lost. Every school key is made right in my shop using special blanks provided by just two key manufacturers."

He adds that whenever a building is constructed or renovated new locks are installed and keys made. Most of the time, "the factory and I coordinate the job together. They make the locks and install the hardware; I install the permanent lock and maintain the system." A soon-to-be-computerized file of 7,000 key codes ("the cut of the key") enables him to create new keys, duplicate keys, and set up locks as needs arise.

Mancini was a construction worker and union carpenter before he joined the WPI staff. Day to day, he says, "you learn by trial and error." He notes that the trade has been changing as the industry expands to include computerized locks, electronic locks, and alarm locks.

Although students sometimes test his skills and patience—"They kick off the door knobs or put shaving cream and glue into the locks"—Mancini remains philosophical. "I expect that here, because the kids come here to study and also to have a little fun. It's par for working at a school where kids will be kids."

Despite the frustrations, and his view that the shop "needs more than two hands to operate," Mancini says he loves his work: "The people are nice, and management is great—very knowledgeable and conscientious."

John E. Miller oversees the planning and upkeep of 1.1 million square feet of building space, the 62-acre campus, and housing for 3,500 students.

Michael Carroll

Administratively, the department oversees the operation of the 800-line telephone system; internal material acquisitions; purchase order preparation for goods, services, and contracts; and approximately 3,000 work orders a year. In addition, he says, "We lead the safety efforts on the campus." Miller is chairman of the Campus Safety Committee, which is "concerned with fire safety, the right-to-know law, hazardous waste disposal, and machine shop and general safety."

A total of 60 employees staff the operational division of Plant Services, which includes the power house—"We have three boilers and use more than a half-million gallons of heating oil each year"—the buildings department, which handles custodial duties; the grounds

John M. Cuth '72 ME:
Snow and Sports in Marquette, Michigan

As manager of trades and utilities at Northern Michigan University, John M. Cuth is responsible for an annual budget of $1.4 million, 67 buildings encompassing six million square feet—including all building systems, heating, ventilation, cooling, and operation—and maintenance of the central heating plant. But because of the university's location, Cuth deals routinely with problems most college plant administrators never face.

The 300-acre main campus (an additional 175 acres is used for summer research camps) is located on the shores of Lake Superior in the city of Marquette, which Cuth describes as "the fourth coldest place in the lower 48 states," with 250 to 300 inches of snow each year. Although his department is not charged with snow removal, he says that "the challenges include the heating load and the added sense of urgency if things aren't working when it's minus 35 and the winds are blowing."

In addition, Cuth says he has to contend with "a very, very short construction season," which has an impact on the timing of such projects as repairs and outdoor painting. "There's snow on the ground as late as the last week in May and generally by the first of October," he adds. "We're in a rural area, 175 miles north of Green Bay, Wis., and 80 to 90 miles from the nearest interstate highway. We have a lot of trouble getting all kinds of supplies and materials, which has an impact on scheduling and planning."

In February 1985, the university was one of only three to be designated a training center by the United States Olympic Committee. Ground breaking for a new sports complex with an enclosed dome—the largest clear span wood structure in North America—took place this fall.

The Michigan State Track and Field Games were held on the campus in August. More than 4,000 athletes were on campus for three days of competition. Cuth's department responsibilities included providing shuttle buses, 600-amp service, scaffolds, and staging. "It was a tremendous organizational experience," he says.

Cuth says that because physical plant is second only to personnel in cost for an organization, good management and maintenance "can be translated into large dollar savings.

"We as engineers have to sell our programs and show the cost advantages of a first-rate maintenance organization, particularly with regard to problems like shrinking enrollment and cutbacks in funding." Of engineering as a whole he says, "It's an interesting profession. People never call you and say, 'Thanks a lot, my roof isn't leaking.' People call when they have problems."

department; and the trades group, a manager and 12 employees responsible for technical maintenance like carpentry, plumbing, electrical work, heating, painting, and lock and door repair.

Miller's annual budget, he says, is about $3.9 million, which represents 10 percent of the college's budget. Deferred maintenance is one of the major challenges in keeping the plant up to date. The buildings are of different types, uses, and construction. They were built over a number of years—the oldest is nearly 125, the newest just two years old. All are unique, and they wear out. Every organization that has a physical plant must recognize that buildings are constantly, perhaps imperceptibly, deteriorating. If there are no funds for upkeep, owners can accrue a "debt" to their buildings that will be expensive to pay off.

"If classrooms weren't open in the morning or the dormitory showers ran cold, the campus would be a very different place."

"In general, that has not been the case at WPI over the years," says Miller. "We want to keep it that way by aggressively budgeting and planning over a special time cycle the maintenance and replacement of major building components." Based on the types of buildings, he adds, an organization can be expected to spend 1 to 2 percent of the replacement value of the buildings in annual maintenance. If the buildings average over $100 per square foot in value, $1 to $2 million could be the cost of day-to-day and long-term maintenance.

William R. Grogan '46, dean of undergraduate studies, underscores the importance of Miller's goals to the entire

Frank Kuszpa '68:
Growing with the University of Hartford

"The challenge for administrators is achieving a balance between the academic and operational needs of colleges and universities," says Frank Kuszpa, assistant vice president for operations at the University of Hartford in West Hartford, Ct. "There will never be enough money to run the campus as we'd like to. The issues are balancing the budget and providing education at a college without sacrificing the facilities."

Kuszpa was director of physical plant at the university before assuming his current post in 1986. He is responsible for a 175-member staff and supervises all physical plant operations for the 8,000-student liberal arts college.

He also serves as president of the Southern New England Association of Physical Plant Managers and is secretary of the national organization. After graduating from WPI in mechanical engineering, he went on to earn a master's in mechanical engineering from Rensselaer Polytechnic Institute, and is completing an executive M.B.A. at the University of Hartford.

"Engineering gave me a great background and taught me logical thought processes," he says. "But being successful in my work means going out and talking with people. I don't like sitting in an office and shuffling papers. I visit students, faculty members, and deans to discuss their concerns and problems." Kuszpa agrees with Malcolm Forbes, who said that his most important resources were the people who reported to him. "I am very much that way. I see myself as mentor to my staff."

The University of Hartford was founded almost 30 years ago. "As you reach 30," says Kuszpa, "maintenance starts piling up." He recently formulated a capital spending plan that has placed all university projects in one computer data base: "This way, when the time does come to make a decision between academic programs and other needs, you can make an educated choice."

The university is growing, with several projects on the books or under way: an 850-bed dormitory, a new physical education center, and a $21-million university center, expect to be completed in September 1988.

"We're toward the end of a $30-million capital campaign, and generating funds for plant maintenance has been one of our major challenges," he says. "You could construct all these buildings and you approach a company and say, 'Wouldn't you like to give a million dollars toward the maintenance?' They want to see their money in concrete or their names on the building. Donors generally aren't interested in saying, 'I'm helping to keep the place clean.'"

David R. Collette '67: Serving Mount Holyoke

Asked to describe his job, David R. Collette '67, Mount Holyoke College's director of physical facilities, says laughingly, "I'm responsible for everything that's broken." He then explains, "I have about 200 people working for me: custodians, housekeepers, craftsmen (plumbers, painters, steamfitters, carpenters, electricians), office staff, storekeepers, general laborers, and groundskeepers."

Mount Holyoke, founded in 1837, is the country's oldest institution offering higher education to women. The 800-acre campus, located 12 miles north of Springfield, Mass., has 100 buildings with 2 million gross square feet. Approximately 1,950 female students are enrolled in undergraduate and a limited number of graduate programs.

Collette says that as a women's school, "the challenges are different—security problems are higher, damage problems are lower," but adds that Mount Holyoke, like other private institutions, share needs to hold the line on spending in spite of a growing facility.

Mount Holyoke is celebrating its 150th birthday this year, and members of Collette's staff are responsible for maintaining everything from the earliest structures—"Some of my housing units were built before 1800"—to the new, 65-stall equestrian center, which is part of the physical education facilities. A new campus center, expansion of the library, and the construction of an academic building for the language department are planned for the future.

Collette says of his work, "It's a service position, so you get the joy of meeting the needs of an academic community. Personally, I like working with people directly, seeing them grow, making them better managers and better workers, putting fun in the workplace." Any maintenance position has an image problem, he claims. "Maintenance people feel insecure more than they should. My own personal feeling is that the relationship between maintenance people and faculty at Mount Holyoke is excellent."

Collette, who has a master's degree in business from American International College and has held his current post for two years, says that in order to succeed at the job, "You have to be a good manager and a good engineer."

"In large part, prospective students measure colleges in terms of what they can touch and see."

educational program. "If the classroom buildings aren't open in the morning," he says, "or the showers in the residence halls don't have hot water, the campus would be a very different place to live in and to operate." To a certain extent, he notes, Plant Services provides all those things we take for granted—"And they do it day after day. People only think of them when something goes awry."

Plant Services also plays a less obvious role, he adds. In a college with 2,600 undergraduates, it's vital that the ambience of the campus and buildings be maintained: "There really are only two states for a college campus," Grogan claims: "very well maintained, where the staff respects and continues that high quality of maintenance; and one that when things start to slip, they very quickly go all the way with graffiti, holes in the walls, junk on the lawn, and broken windows. It takes considerable energy on the part of Plant Services to maintain the top state. We feel we have a very attractive campus here. It has a big effect on admissions." Especially at the price of a WPI education, he says,

Completed in 1985, the 225-bed Founders Hall was the largest construction project undertaken by WPI. Now on the drawing board is Fuller Laboratories, a $6 million information sciences center (inset).

"Nobody wants to live in a dump!"

Robert G. Voss, executive director of admissions and financial aid, says that a survey of undergraduates admitted for 1986 revealed that 92 percent of the respondents said that campus appearance was an important factor in their selection of the college. Other items included project activities, which rated first at 95 percent, and quality of labs and student activities, rated at 93 and 91 percent, respectively.

Voss says that a positive campus image is an important marketing strategy: "If people perceive our campus to be pleasing, and it's important to them, then we want to promote that fact. It's awfully difficult to measure the quality of academic programs. Students have a heck of a time figuring that out, so they often measure colleges in terms of what they can touch and see."

"The physical plant is incredibly important to the functioning of the college," Miller claims. "It provides the roof; it provides the services. The plant people do their jobs and more. We're responsible for so many of these little things for so many people. We're the service sector."

The department's toughest job, he says, is realizing its importance and the importance of the services its people provide. "It's sometimes difficult to find our role in such a sophisticated environment," Miller says. "The service we provide at this college is essential to its operation. These needs exist, and they have to be addressed."

Bonnie Gelbwasser is a freelance writer living in Rutland, Mass.

Winthrop M. Wassenar '59, '60 MCE:
Williams College Director Finds His Job Interesting and Frustrating

Winthrop M. Wassenar '59, of Williams College in Williamstown, Mass., says, "The job at different schools varies. At the larger ones, planning and plant are separate; at Williams, what I do is serve as director of facilities and planning.

"The job has two parts: the day-to-day maintenance and operation of the campus from the custodial to the grounds crew with responsibility for all the trades necessary to keep a large plant going, and planning, accomplished with a full-time staff, including a registered architect, a registered mechanical engineer, and a registered civil engineer." Wassenar himself is a registered civil engineer and a member of APPA, the Association of Physical Plant Administrators.

Wiliams College, founded in 1793, is an undergraduate college (there are also two master's programs) with an enrollment of about 2,000 men and women. The central campus encompasses 450 acres with 98 buildings totaling approximately 1.8 million square feet. The college owns an additional 2,500 acres including the 2,000-acre Hopkins Memorial Forest.

Wassenar administers an annual operating budget of approximately $8 million and says, "For the last two years, the total value of construction projects in progress has been averaging about $20 million. In the last 20 years, we've built a new science center, dormitories, track, football and baseball fields, a new infirmary, two additions to the Williams College Museum of Art, and a new library and field house."

His office is involved from the initial conception of a project. Once that decision is made, he notes, he gets involved with the interview and selection of the architect and then shepherds the whole design process through the various stages to the point of going out to bid. "We supervise the construction of the project to occupancy, and then we maintain and operate it forever more. It's a total facilities aspect, from inception to design to construction, occupancy, and day-to-day operation.

"I personally get more pleasure out of the planning and creative aspects of the job," he says. "The other aspect I think is really rewarding is dealing with the students, who can be both interesting and frustrating, the faculty, the administration and, in a small town like this, the community. The frustrations are like those in any job—like when the power goes out in the middle of the day and the computer shuts down . . . It adds to the excitement."

By Paul Susca

In Praise of What Persists

If engineering students can graduate without tackling science and mathematics courses, those subjects can't be too important to the field. Not so, say top educators.

Michael Carroll

Physics Professor Robert Long says that the department recommends courses in modern physics to few students because "they aren't going to get much out of that that's applicable to what they're doing in later life." Classical physics is still the mainstay of physics education for undergraduates.

Engineering does not stand on its own; it stands on the shoulders of science. That point is often taken for granted, but every once in a while someone suggests that engineers don't use much science, and that therefore engineering students only need to be exposed to just enough science and mathematics to get by in their engineering courses.

WPI's experience with the evolution of the Plan (*WPI Journal*, August 1986) has revealed the idea that science might be superfluous for the engineering student. In fact, William Grogan '46, dean of undergraduate studies and one of the chief architects of the Plan, recalls that when science requirements were removed in the Plan's early years, students stopped taking those courses.

"Word got around," Grogan says today, "that they could pass their engineering courses and their Competency Examinations without having taken the traditional math and science courses." That was true, he adds, "because the engineering courses tend to be stand-alone events; whatever science is needed is presented in the course."

The science and math requirements were reinstituted in 1986 at the insistence of the Accreditation Board for Engineering and Technology (ABET). But if WPI students managed to graduate and to function in their engineering careers without math and science courses, are they really needed?

Grogan poses a different question: What's important, he says, is not whether every engineer *needs* science to function, but whether science *should* be in the background of an engineer? "I would say very definitely yes, absolutely," he answers. The same holds true for humanities: "It's just plain good education. An educated person, whether an engineer or a liberal arts graduate, should understand the nature of the universe in which he or she lives, as explained by scientific principles."

A command of scientific principles offers more than an understanding of the world in which we live; some argue that an education that focuses on technology without relying heavily on the scientific basis of technology does not prepare students to be engineers at all, but to be technologists. But while the prevalence and variety of technology in modern society has created a niche for innovation for the new class of technologists, the practice of engineering has come to rely

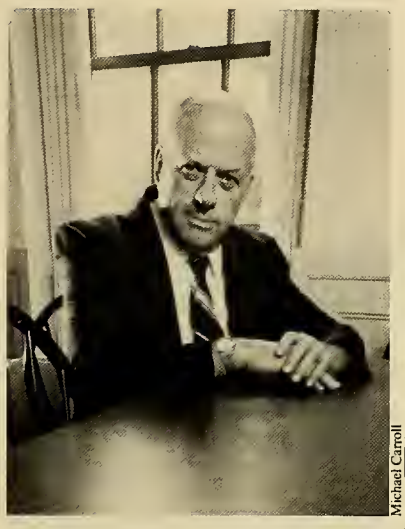
even more heavily on basic science.

In the field of mechanical engineering, for example, advances in physics and mathematics have led to the relatively recent development of nondestructive measurement techniques. One of those techniques, laser Doppler anemometry (LDA), which is used almost daily in Mechanical Engineering Professor William Durgin's fluid mechanics laboratory, is based on laser techniques developed by physicists. LDA makes possible the measurement of air velocities anywhere in a wind tunnel without putting an instrument inside the tunnel. The technique was first developed around 1970, Durgin says, and is now used routinely around the country.

A look at the science curriculum shows how close the relationship is between cutting edge science and new technology—so close that the line between science and technology becomes blurred. The physics department, for example, offers courses in multilayered semiconducting heterostructures and optoelectronics, two areas that are revolutionizing electronics. And just across the street, biology and biotechnology has courses in fermentation and downstream processing, relying on biology to expand the horizons of process engineering.

The increasing interactions between fields, especially the life sciences and various engineering fields, make an even stronger case for a solid grounding in science, says Robert H. Goff '52, associate dean of engineering at the University of Rhode Island. Goff cites the importance of biology to environmental problems faced by civil engineers, physiology applied to robotics, and, of course, biotechnology. "I think we want more creativity out of our engineers—less being the technician," says Goff. "And I think you're more apt to function in a creative fashion if you have a broader basic science background."

But short of increasing the number of years required to earn a bachelor's degree in engineering, boosting the basic science content of engineering programs would involve some trade-off of engineering design skills. In a conflict between the science basics and engineering practice, some criterion must be found that can be relied upon to measure the long-term value of the two competing aspects of engineering education. The test that educators often apply in this comparison is the question, What aspect of education endures longest?



Michael Carroll

"Science *should* be part of every engineer's background. It's just plain good education," says William R. Grogan '46, dean of undergraduate studies.

"The important thing," says Goff, "is that the graduates realize that there is a lot they never learned in school, some of it because it was unknown at the time. Therefore, if they're going to stay on the cutting edge of what's happening, they've got to be learners for the rest of their professional careers."

Surveying the continually shifting landscape of high technology—microelectronics, optoelectronics, computers, and the entire field of biotechnology—Donald E. Sands '51 also sees an increasingly strong case for science. Sands, academic vice chancellor at the University of Kentucky in Lexington, says, "If there's one lesson in all of this, it's that we can't predict what the future will hold, and our students do need to be prepared to continue their learning. Whatever they learn now is going to be obsolete in a few years."

Bill Durgin echoes the idea of the durability of a solid background in science. "I was educated under the philosophy that if one understands the basics well—and by the basics I mean the math and science underlying our field of engineering—then one can address any new fields that come along or any new applications that come along," he says. "And I've always found that to be true in my experience."

There is a large school of educators who favor bolstering the science content of engineering education for that very reason, says David T. Hayhurst '72, chairman of the chemical engineering department at Cleveland State University. He cites separation processes as an example. Distillation has long been taught as a separation process, but industry is moving increasingly into other separation methods such as adsorption. "Some people feel we should be giving students a fundamental understanding of the basic mass transfer concepts, says Hayhurst. "Let industry, they would say, bring students up to speed with the state of the art."

If the role of advanced techniques in engineering practice yields ground to an increased emphasis on underlying scientific concepts, then industry has to take up the slack. But according to Professor of Electrical Engineering James Demetry '58, that has long been the case. "Companies take in young, bright people with four years of engineering school, and they teach them what they have to know to be productive and creative people inside the company. I don't think they

expect them to be productive from day one."

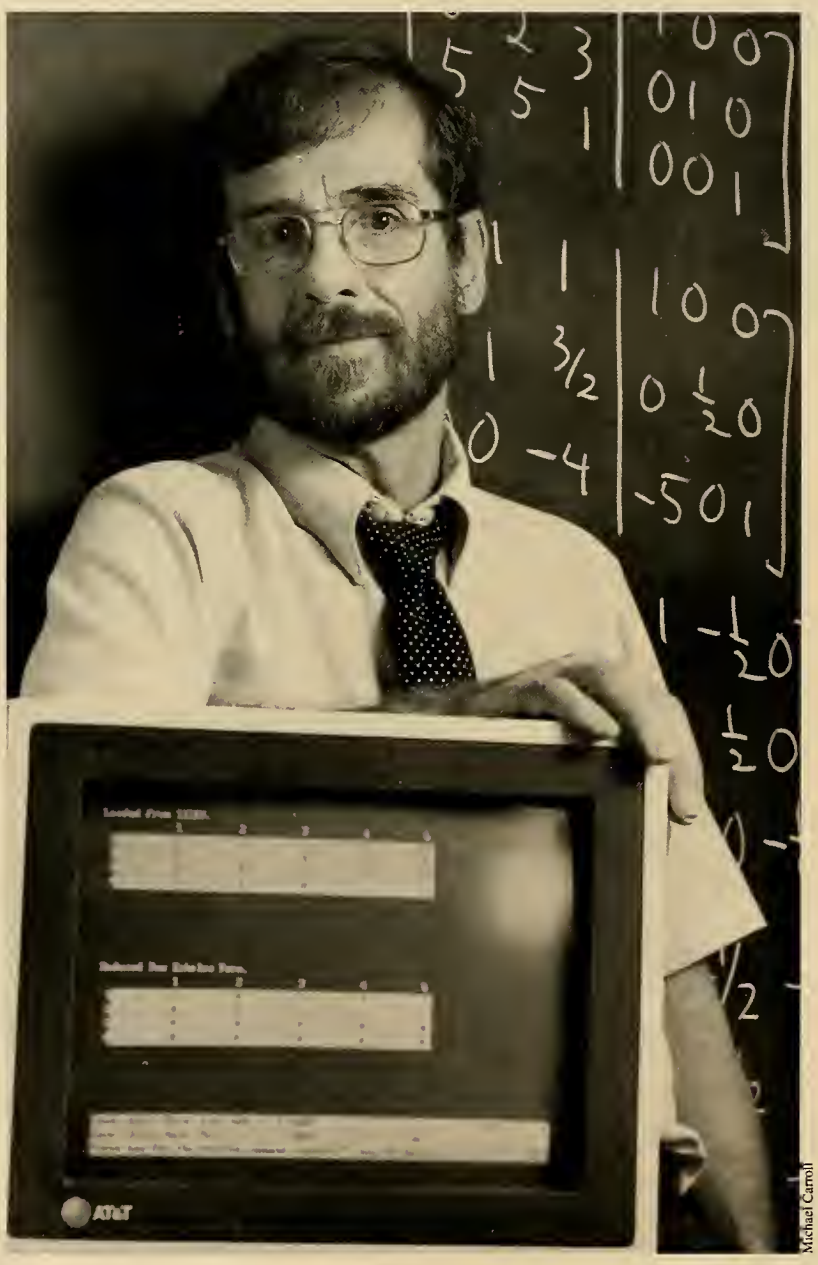
Grogan also champions science and mathematics for the durability and flexibility they provide to graduates. "We tend to be very application-oriented," Grogan says, "sometimes at the expense of understanding. I think the price we pay for that is ultimately a lack of flexibility on the part of students. Once the technique they learned is superseded by a newer technique, too often students do not have a depth of understanding of the scientific principles that enable them to adapt to a new situation."

That aspect of the relationship between science and engineering is nothing new, the former electrical engineering professor points out. "The historical evolution of engineering is from science. So in a highly changing technology, a deeper understanding of science would seem to be a more durable element in education than the more volatile state-of-the-art technique."

The durability of science is borne out by how little freshman science courses have changed over the years. True, says Robert Long, professor of physics, the advances that have taken place in physics in the last 50 years have led to previously unimagined developments in nuclear and electronic technology and sophisticated instrumental methods used in chemical analysis. Still, he says, the department recommends its course in modern physics to few engineering students. "They probably won't get much out of the course that will be directly applicable to their future careers," Long says. Because of its lasting relevance, classical physics is still the mainstay of the physics background for undergraduate engineers. The same is true of mathematics, chemistry, and biology: Material that is presented to students in the first few courses has not changed radically over the years, except when it has been updated to reflect new knowledge.

There is, however, a movement afoot nationwide in the mathematics community to investigate to what extent courses in discrete math should be introduced into the first-year curriculum for scientists, engineers, and mathematicians. This, says J. Richard Lundgren '64, chairman of the mathematics department at the University of Colorado at Denver, is because of the ubiquity of computers and the need for computer users to exploit the machines' use of finite math, as opposed to the traditional calculus that

Professor of Mathematics J.J. Malone says that because students don't think in terms of long-range goals, "they often look upon the math and science as a necessary evil."



Michael Carroll

every technically inclined freshman learns.

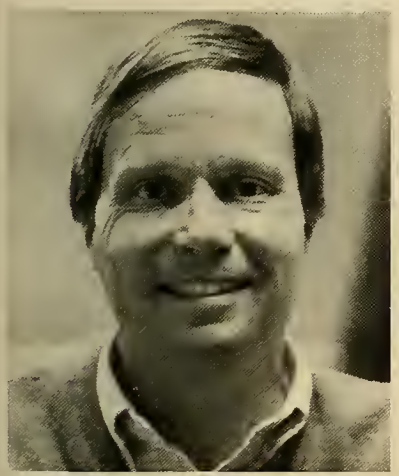
A computer is a finite machine, Lundgren explains, meaning that much of what it does can be shown on a graph with discrete points rather than the smooth lines characteristic of calculus. So computers handle information in a very different way than it is often described in calculus. Finite math is also useful in choosing how to structure data in a computer program, Lundgren says. And the importance of finite math to engineers will continue to grow, he adds. "This field of mathematics is absolutely essential to building models and solving problems using supercomputers and parallel computers, which engineers will find themselves using more and more."

In upper-level courses, Lundgren notes, a significant advance is the increased activity in computational math—the development of numerical methods and algorithms for use in solving physical problems on the new generation of supercomputers.

This already accounts for a major part of Lundgren's department at Colorado. And he is already seeing many undergraduate engineering students taking as electivcs, in addition to the required math (the calculus sequence, differential equations, and linear algebra), such courses as discrete (finite) math, mathematical modeling, and numerical analysis—all prompted by the needs of technical computing. "In 10 years," he claims, "you'll see a revolution in the teaching of mathematics."

As the importance of various types of mathematics shifts, what does that portend for the courses recommended for engineers? Professor of Mathematics Gordon Branche says the growing importance of numerical data analysis necessitates an understanding of its mathematical underpinnings. But he notes that the question of how to make room for the new material is a delicate issue. Eventually, he says, some kind of accommodation will have to be made between adding more material or courses and shifting the emphasis of the courses that are currently required. But the process of assimilating discrete math into engineers' preparation is a slow one, Branche says, because it is not exactly clear how the math is going to be used.

To make matters worse, students already in the dark about the applications of the math they are learning can often look forward to at least two more years



"Finite math is absolutely essential to solving problems using supercomputers," says Colorado's J. Richard Lundgren '64.

University of Rhode Island Dean Robert H. Goff '52: "We want more creativity from our engineers—less being the technician."

of study without using it. Branche says that sophomore and junior engineering courses sometimes fail to reinforce freshman calculus, so by the time senior year rolls around students have lost whatever calculus they once knew. "One of the things I would like to see as we incorporate discrete math is that we somehow have to reinforce calculus concepts," Branche says, "because calculus is cumulative."

Although science courses have remained relatively stable over the years, the relationship between science and engineering, particularly the role of science in engineering education, has changed. Since its emergence as a discipline during the Industrial Revolution, engineering was taught essentially as a set of skills. William Grogan characterizes the state of engineering before World War II as "rather stodgy, very pragmatic." But the military importance of radar and electronics in general, Grogan says, "kicked up the scientific component of engineering significantly. Then it plateaued and Sputnik kicked it up again."

Mason H. Somerville '64, dean of the College of Engineering at Texas Tech University, sees Sputnik as the catalyst that precipitated a major shift away from the "technology-based curriculum" he graduated under, comprising design courses, hands-on lab courses, drafting, machine shop, and foundry in addition to theory courses. As the U.S. space program was stepped up, he believes, it became much easier to get funding related to the space race, and the emphasis of engineering research and teaching shifted toward high technology—meaning engineering science—which in turn required engineers to have more math and science background. As a result, Somerville says, students became much more proficient at math, science, and engineering science at the expense of the traditional engineering skills.

As the practice of engineering has become more scientific, engineering departments, in response to the accrediting boards, have prescribed more math and science to prepare their graduates for the demands of their careers. But students don't always swallow their teachers' prescriptions without question. According to Professor of Mathematics J.J. Malone, chief architect and teacher of linear algebra courses at WPI, "Students have fairly immediate goals. Sometimes it's hard for them to be tolerant of the goals that fit into the long-range goals. So they often look upon the math and science as a necessary evil, and they even question the 'necessary' part of that."

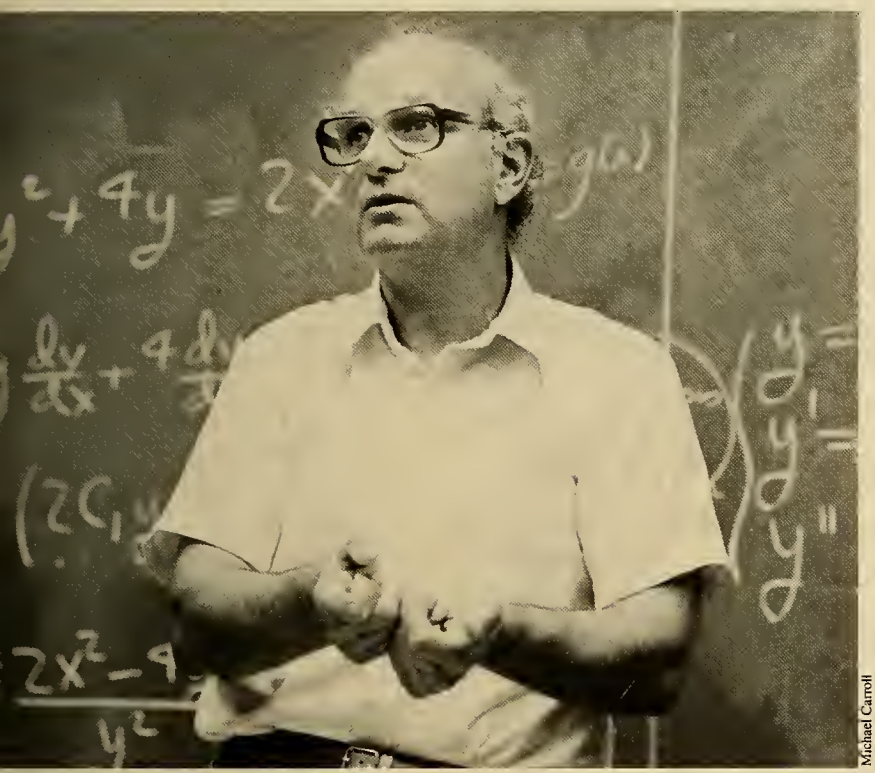
At Cleveland State, David T. Hayhurst '72 has brought in engineers with industrial experience to teach math to chemical engineering students.

Malone has seen the annual enrollment in linear algebra courses, which typically come after calculus and differential equations—usually some time in the sophomore year—grow from less than 80 to over 400 in his time at WPI. "That's not because students have the foresight to anticipate the need for linear algebra," he claims, but because many of the engineering departments, particularly electrical engineering, specifically recommend the courses." But because students sometimes question the need for more math, Malone feels it is the joint responsibility of the mathematics and engineering departments to show students that it is indeed necessary.

In 1984 Malone advised a student doing an Interactive Qualifying Project (IQP) that successfully sought to identify applications of linear algebra in undergraduate engineering courses at WPI. Now, Malone says, "You can say to students, 'In your first chemical engineering course, here is how you used linear algebra. And in your early electrical engineering you used systems of equations to figure out circuits. And in civil engineering you're using eigenvalues to study questions of structural stability.'"

David Hayhurst says his department has found a different way to address the question of the relevance of mathematics material to engineering students. At Cleveland State, engineers with industry experience are brought in to teach math—in particular numerical methods using computers—as part of the core curriculum in engineering sciences. That's after students have already taken the usual courses in calculus, linear algebra, and differential equations.

A mathematics professor, Hayhurst says, does not have the experience to teach the numerical methods course at the same level that a seasoned engineer can. At a large university, this approach to teaching numerical methods, which concentrates on subjects rather than departments, can result in some turf battles. Hayhurst says that "Every time the mathematics department asks us what we're teaching, we tell them it's engineering, but the engineers swear it's mathematics. Most likely, this is a phenomenon that is not unique to Cleveland State, but is shared by many institutions."



Michael Carroll

As new directions in math emerge, says Dr. Gordon C. Branche, associate professor of mathematics, "we'll have to decide how best to make room for the new material in an already crowded curriculum."

What will be the next episode in the saga of engineering and science is anybody's guess. But some educators are willing to do some crystal ball gazing. Citing the eroded competitive position of the United States in manufacturing and the Soviets' leading position in space with an almost continually manned space station in orbit for several years, Bill Durgin thinks the time may be ripe for another upheaval like the one that followed Sputnik.

Mason Somerville says Star Wars may turn out to be the next landmark event, although it is hard to say what its impact will be. In any case, Somerville sees a division of labor between engineers and technologists. Because major advances in technology depend on exploiting basic phenomena—molecular and even subatomic—engineers with substantial math and science backgrounds will work on the cutting edge.

Technologists, those with associate degrees in engineering or B.S. degrees in technology, will become the stewards of existing technology, operating and maintaining the economic and industrial infrastructure and implementing its slow evolution. Somerville also suggests that the rise of educational programs for technologists was sparked by Sputnik in the first place.

As far as the next chapter of engineering education is concerned, Donald Sands hopes to see it borrow a page from science, tempering engineers' tendency toward certitude with shades of gray. One of the things that science teaches, Sands says, is a sense of its own limitations. Sometimes this readiness to admit what isn't known even shows up as basic principles of science, such as the Heisenberg Uncertainty Principle, the second law of thermodynamics, and Goedel's Proof in mathematics.

"I'd like to see engineers impressed more with shades of gray," he says. "Engineering tends to be deterministic: If you connect this to this, the current will run from here to there and there's no doubt about it. Well, the real world is made up of lots of shades of gray."

THE PRESIDENT'S MESSAGE

WPI, Inc.

By Dr. Jon C. Strauss

Industrial involvement is both one of the oldest and one of the newest emphases for WPI. It is the oldest in the sense that it was the *raison d'être* for the industrial and community support that brought WPI into being as the Worcester County Free Institute of Industrial Science in 1865. And today, the rebirth of interest in industrial manufacturing is the key to the nation's international competitive strength. Cooperative ventures uniting universities and businesses are expanding nationwide in such high technology areas as aerospace, artificial intelligence, biomedicine and biotechnology, materials, microelectronics, nondestructive testing, and superconductivity.

Ichabod Washburn, one of the founders of WPI, built the Washburn Shops to house a for-profit manufacturing business in which WPI students could apprentice to learn firsthand the manufacturing skills and techniques of the day. In the 1890s, the increasing profitability (and competition) of the Shops had become such a *cause célèbre* with local industry and tax officials that the trustees of the college voted to de-emphasize for-profit manufacturing. As a result, Milton P. Higgins, the first superintendent of the Shops, resigned, along with his friend Prof. George Alden. The two went on to build Norton Company, which they had founded, into an international force in industrial abrasives manufacturing.

At that same time, Milton Higgins bought the rights to the hydraulic elevator that he had invented and manufactured in the Washburn Shops. Subsequently, he sold the rights to Otis Elevator, setting the stage for the company's rise to prominence. Higgins also founded the Worcester Pressed Steel Company, and a son-in-law, R. Sanford Riley, founded Riley Stoker Company. At about that time, H. Winfield Wyman '82 and Lyman F. Gordon '81 co-founded Wyman and Gordon Drop Forge Company; Charles Morgan, a founding trustee, established Morgan Construction Company; and alumnus James N. Heald founded Heald Machine Company. Obviously, WPI had enormous influence on the growth of Worcester as an industrial power in the late 1800s and early 1900s.

At WPI, this involvement with the real work of the world continues today. Its scope now extends considerably beyond the borders of Worcester County, and it manifests itself in many ways:

• Our trustees constitute a virtual *Who's Who* of American business and industry. They range from Fortune 500 presidents, such as Robert C. Stempel '55 (General Motors Corp.) and Paul A. Allaire '60 (Xerox Corp.), through investors and entrepreneurs, such as Howard G. Freeman '40 (Jamesbury Corp.) and S. Merrill Skeist '40 (Spellman High Voltage Electronics Corp.); to entrepreneurial leaders of small businesses, such as Raymond J. Perreault '38 (Falls Machine Screw Company), Robert H. Beckett '57 (Robec Distributors), and Irving James Donahue, Jr., '44 (Donahue Industries). In other dimensions, we find a financial leader in F. William Marshall, Jr., president and CEO of Shawmut Worcester County Bank; a utility executive in Samuel Huntington, president and CEO of New England Electric System; an attorney in C. Marshall Dann '35, former U.S. Commissioner of Patents and Trademarks; and educators, such as Prof. John J. Gabarro '61, of Harvard University Graduate School of Business; and Prof. Carol L. Reinisch, of Tufts University School of Veterinary Medicine. These and other board members are positioned well to help attain for WPI the recognition it deserves now and will continue to earn in the future.

• Our alumni, too, are well represented at all levels in the world of business and industry. In addition to those listed as trustees, several worthy of special mention for what they bring to WPI include Paul W. Bayliss '60, vice president for market planning and management of AT&T's Network Systems, and past president of the Alumni Association; Richard J. Kennedy '65, vice president of the Abrasives Marketing Group at Norton Company and president of the Alumni Association; George T. Abdow '53, founder and president of Abdow's Big Boy Family Restaurants; Michael A. DiPierro '68, president of Polyform Corporation; and Gordon H. Sigman, Jr., '59, vice president of strategic defense programs for United Technologies Corp. These and other alumni bring enormous talent to the service of WPI through the Alumni Association, departmental advising committees, and outreach activities of all kinds.

• It is among our faculty, however, that we see the real involvement in the development and application of new technology for the benefit of American industry. It takes many forms:

  • Prof. Ronald R. Biederman of Mechanical Engineering has for many years led an interdisciplinary program in materials science, working directly with companies like Wyman Gordon, Morgan Construction, Norton Company, C. R. Bard, General Dynamics Electric Boat, and AMP on applications ranging from ceramics to forging, powder metallurgy, and steel rolling, as well as biomaterials for artificial joints and angioplasty. Working closely with Dr. Biederman are Profs. Sara A. Dillich, Gary L. Leatherman, Ryszard Pryputniewicz, Richard D. Sisson, Jr., and Floyd R. Tuler.

  • Profs. Alex E. Emanuel, Dave Cyganski '75, and John A. Orr of Electrical Engineering are doing exciting work under the sponsorship of the Electric Power Research Institute, investigating

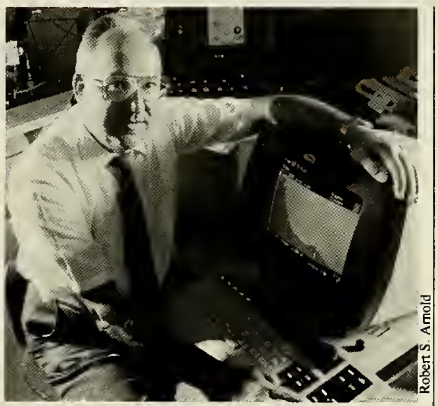
the effects of harmonics produced by photovoltaic generation. In addition, Drs. Cyganski and Orr are also supported by Teledyne Corp. for work in vision systems for integrated circuit manufacturing.

• The Manufacturing Engineering Applications Center (MEAC), directed by Prof. Donald N. Zwiep, head of Mechanical Engineering, is both a laboratory for developing automated manufacturing processes and a program where industrial sponsors support generic research and proprietary projects for their own manufacturing processes. Digital Equipment Corp. (DEC), Emhart Corp., General Electric (GE), and Norton Co. have received significant benefits from their annual sponsorship of MEAC.

• The Management of Advanced Automation Technology (MAAT) program, directed by management Prof. Arthur Gerstenfeld, also works closely with industrial sponsors, including Barry Wright Corp., Combustion Engineering Corp., DEC, GTE, GE, Lockheed Corp., Polaroid Corp., and Wyman Gordon.

• Prof. Yi Hua Ma of Chemical Engineering has just organized a new center in inorganic membrane technology with support from Alcoa Co. He is joined in this effort by Profs. William M. Clark, Anthony Dixon, and William R. Moser, as well as Profs. Biederman and Sisson.

• One of our newest industrial joint ventures is the Center for Computer-Aided Engineering (CAE) for Manufacturing. This center derives from Provost Richard H. Gallagher's interest and expertise in computational



The work of Dr. Ronald R. Biederman represents WPI's historic alliance with industry.

mechanics in combination with a number of faculty members, including Profs. George Y. Jumper, Jr., James Kane, and Sunil Saigal from Mechanical Engineering; Paul W. Davis and Janos Turi from Mathematical Sciences; and Thomas A. Shannon from Humanities.

This summer, the center submitted a proposal to NSF for $12 million in support. Industrial sponsors include Avco Lycoming Corp; General Dynamics; Hewlett-Packard Co; Hibbitt Corp; Karlsson and Sorenson, Inc.; Micro Control Systems, Inc.; Norton Co.; Raytheon; United Technologies; and Wyman Gordon.

Of the $3.5 million in sponsored research performed by the faculty in 1986–87, more than 50 percent came from industrial sponsors.

• The Institute has several other forms of industrial support:

  • WPI has an active Cooperative Education Program, which places more than 15 percent of our juniors and seniors in industrial assignments with companies such as DEC, IBM, Raytheon, and United Technologies. Under the leadership of its new director, Carolyn Tidwell, we anticipate that this program will grow significantly in both the number and the quality of assignments.

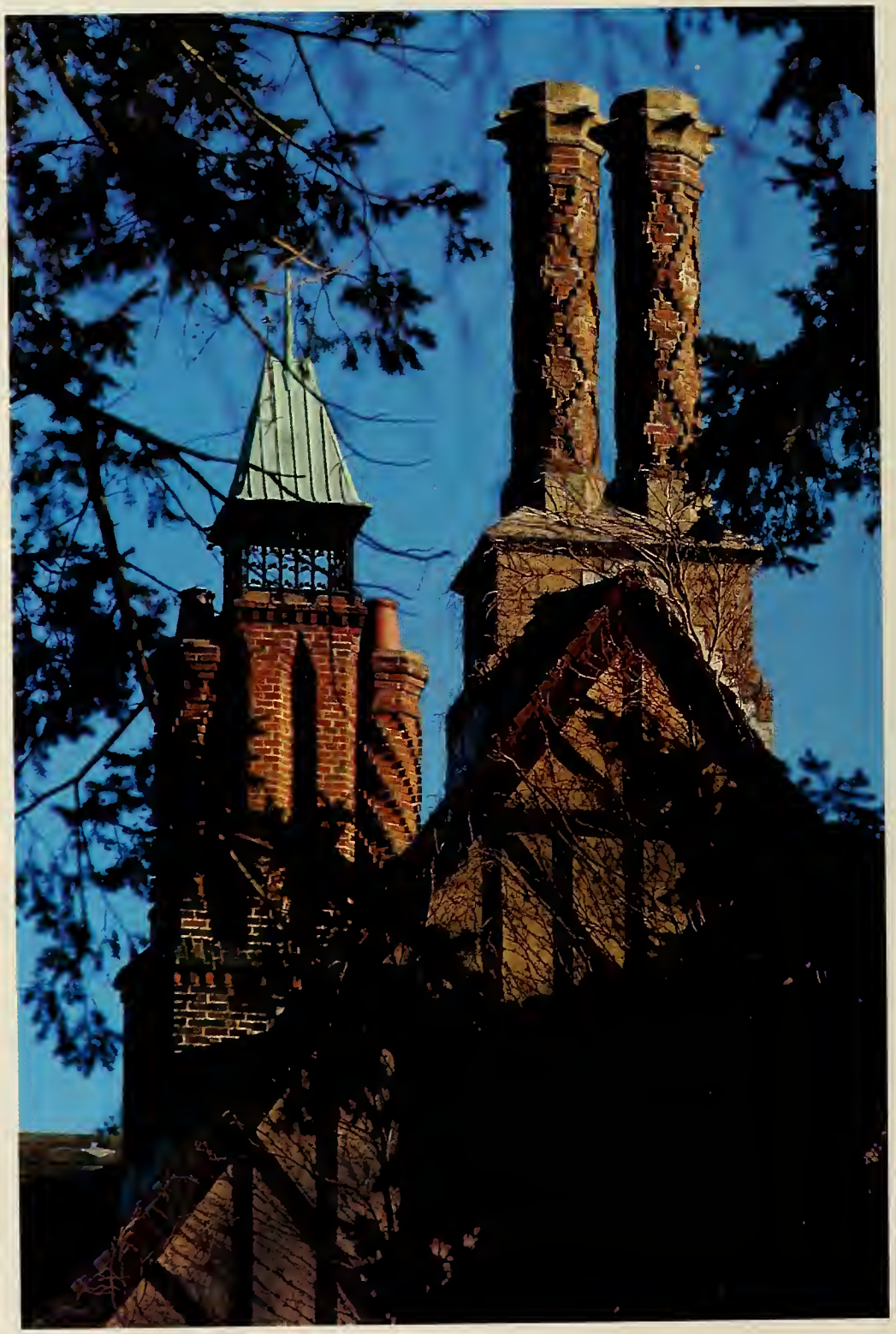
  • Organizations such as ADI, DEC, Raytheon, and Wyman Gordon have found the support of fellowships at WPI to be a good investment.

  • In recent years, AT&T, Convergent Technology, Inc., Datability Corp., DEC, Hewlett-Packard, IBM, Raytheon, Wright Line, Inc., and others have made generous gifts of equipment.

  • Most New England firms have contributed generously to the recent renovations of Atwater Kent and the Washburn Shops and will be given the opportunity to invest further in WPI's continued new building and renovation program as part of the *Campaign for Excellence*.

We are not, however, seeking outright philanthropy in our industrial relationships. Rather, Dr. Ron Baird, director of corporate relations, is trying to establish sustained joint ventures in which the research interests of faculty members align with, and hopefully are sponsored by, industrial partners. We have had significant success with this approach over the first 122 years of WPI's existence, and we are looking to achieve even greater success in the future.

By now, you may well be aware of WPI's *Campaign for Excellence*, a five-year drive to raise $52.5 million to bring new levels of excellence to WPI. While industrial support of faculty research will not be counted in that total, the continuing direct involvement with business and industry that has been so much a hallmark of WPI remains a high priority for the future.

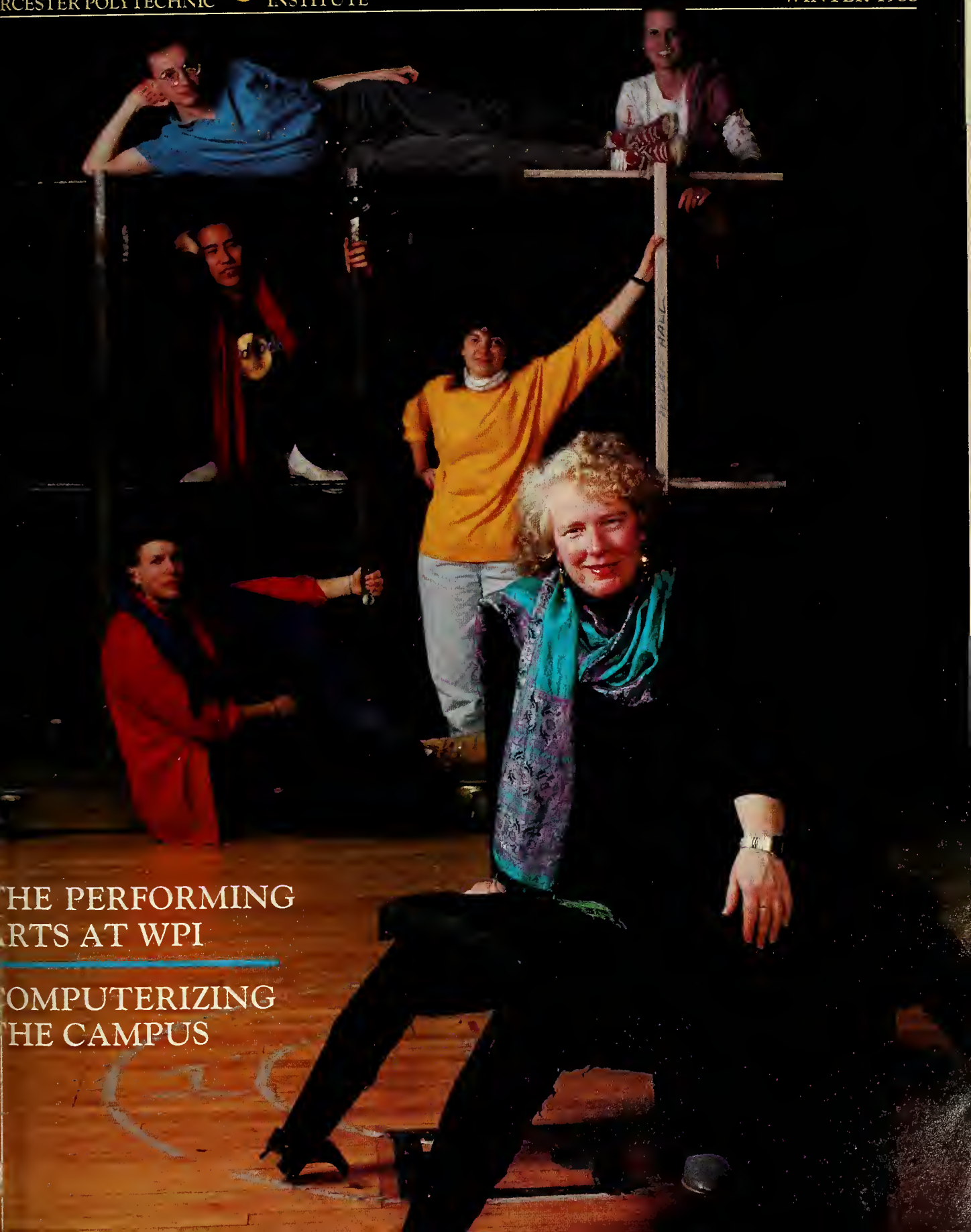


The chimneys of Higgins House in November.

WPI Journal

RCESTER POLYTECHNIC INSTITUTE

WINTER 1988



HE PERFORMING
RTS AT WPI

OMPUTERIZING
HE CAMPUS

Boynton Hall wears its winter finery. Photo by Robert S. Arnold. Black-and-white, 8–by-10–inch prints of this photo are available; send $10 to WPI Journal, *100 Institute Road, Worcester, MA 01609.*

WPI JOURNAL

CONTENTS

VOLUME XCI No. 3
WINTER 1988

Staff of the WPI Journal: Publisher, Kenneth L. McDonnell • Editor, Michael W. Dorsey • Alumni Information Editor, Ruth S. Trask

Alumni Publications Committee: Samuel Mencow '37, chairman • Paul J. Cleary '71 • Judith Donahue, SIM '82 • William J. Firla, Jr. '60 • Maureen Sexton Horgan '83 • Carl A. Keyser '39 • Robert C. Labonté '54.

The WPI Journal (ISSN 0148-6128) is published quarterly for the WPI Alumni Association by Worcester Polytechnic Institute in cooperation with the Alumni Magazine Consortium, with editorial offices at the Johns Hopkins University, Baltimore, MD 21218. Pages I–XVI are published for the Alumni Magazine Consortium [Franklin and Marshall College, Johns Hopkins University, Villanova University, Western Maryland College, Western Reserve College (Case Western Reserve University), Worcester Polytechnic Institute] and appear in the respective alumni magazines of those institutions. Second class postage paid at Worcester, MA, and additional mailing offices. Pages 1–16, 33–48 © 1988, Worcester Polytechnic Institute. Pages I–XVI © 1988, Johns Hopkins University.

Staff of the Alumni Magazine Consortium: Editor, Donna Shoemaker • Wrap Designer and Production Coordinator, Amy Doudiken Wells • Assistant Editor, Julia Ridgely • Consulting Editors, Alan Sea and Elise Hancock • Core Designers, Allen Carroll and Amy Doudiken Wells.

Advisory Board of the Alumni Magazine Consortium: Franklin and Marshall College, Linda Whipple and Patti Lawson • Johns Hopkins University, B.J. Norris and Alan Sea • Villanova University, Eugene J. Ruane and D.M. Howe • Western Maryland College, Joyce Muller and Sherri Kimmel Diegel • Western Reserve College, David C. Twining • Worcester Polytechnic Institute, Michael Dorsey and Kenneth L. McDonnell.

Acknowledgments: Typesetting, BG Composition, Inc.; Printing, American Press, Inc.

Diverse views on subjects of public interest are presented in the magazine. These views do not necessarily reflect the opinions of the editors or official policies of WPI. Address correspondence to the Editor, The WPI Journal, Worcester Polytechnic Institute, Worcester, MA 01609. Telephone (617) 793-6516. Postmaster: If undeliverable please send form 3579 to the address above. Do not return publication.

9 **The State of the Arts** *Amy Zuckerman Overvold*
Music and drama help draw undergraduates to WPI.

I **Photo Finish**
Announcing a contest for our readers.

Learning a Language

II **Words Apart** *Robert Kanigel*
The payoff and the price.

VII **From Foreign to Fluent: What Works?** *Robert Kanigel*
Motivation helps—so do practice and patience.

XV **Translators, Traitors, Transcreators** *Julia Ridgely*
They strive to make foreign authors accessible.

33 **Bit by Byte by Brick by Wire: Putting it Together** *Michael W. Dorsey*
Computerizing the campus.

41 **Making Company, Making Tracks** *Jerome A. Parchois*
The Worcester Consortium for Higher Education.

DEPARTMENTS

2 **Advance Word:** The *Journal* gets a new editor and format.

3 **Communique:** Fostering innovation at WPI. *Jon C. Strauss*

4 **Investigations:** The diffusion of polymers, the genetics of fish food, the mechanics of a cat's knee.

6 **Innovations:** Promoting good teaching.

7 **Inside WPI:** Helping freshmen succeed.

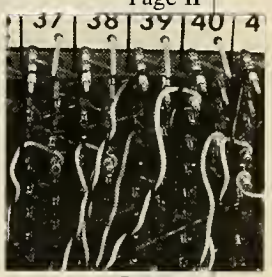
8 **Explorations:** Oil conversions, learning about fire, the link between art and science.

47 **Memory Bank:** The wonderful life of Winthrop Brown. *Roger N. Perry Jr. '85*

48 **Final Word:** Back in the U.S.S.R. with Pat Dunn. *Amy Zuckerman Overvold*

Page 9

Page II


Page 33

Page 41

Page 3

Cover: Susan Vick and some of her "New Voices." Story on page 9. Photo by Janet Woodcock.

ADVANCE WORD

For *Journal* Readers, 1988 Brings New Direction, New Editor

By Donald F. Berth '57

Change is a fact of life for magazines. During its 90 years, the *WPI Journal* has undergone many changes, all of which have helped it better fulfill its mission: informing and enlightening the college's alumni and friends.

Nearly six years ago, WPI introduced to readers of the *Journal* a new look and a new editor, Kenneth McDonnell. We also inaugurated what was, for us, a new concept in magazine publishing, the Alumni Magazine Consortium. All three of those additions—format, editor, and Consortium—have served WPI well.

Last year, the *Journal* evolved still further, as the removal of the Class Notes section (now found in an expanded form in *TheWire*) freed up space for more feature stories and more and larger photographs and illustrations.

With this, the first issue of 1988, we launch yet another phase in the continual advancement of this magazine. Ken McDonnell is moving up to assume the new post of publisher of the *Journal*. Taking Ken's place as *Journal* editor is Michael Dorsey, director of the WPI News Service. Ken continues to serve as editor of *TheWire* and as director of WPI's extensive publications efforts. Ken has served our readers most effectively on the editorial firing line. In his new role, he will be able to exercise more editorial leadership over the *Journal* and our growing array of publications, which are produced for a variety of constituencies.

In this issue, you will also find the first installments of an assortment of regular departments. These departments will keep you up to date on the scholarship and educational achievements of our faculty, show you some of the outstanding projects completed by our undergraduate students, and give you a behind-the-scenes look at the evolving face of WPI.

The WPI* Journal *debuted in November 1897. Since then, it has undergone many changes. In April 1982 the* Journal *acquired a new look and editor, and became part of a publishing consortium. With this issue, the magazine's evolution continues.

And you will find regular commentary on current issues from members of the WPI campus community and from our extended community beyond the campus. Finally, you can look forward to short profiles of interesting people associated with WPI. One thing we are not changing as we enter the new year is our ongoing relationship with the Alumni Magazine Consortium, a group of eastern colleges that band together to produce their alumni magazines. Currently there are six colleges in the Consortium. Along with WPI, they are Franklin and Marshall College, Villanova University, Western Maryland College, Western Reserve College (of Case Western Reserve University), and Johns Hopkins University, which created and manages the Consortium.

While WPI realizes some cost savings by having the *Journal* produced by the combined resources of the Consortium, this is not the greatest benefit of our participation. In the middle of this and every *Journal* produced over the last six years you will find a 16-page section known as the "core."

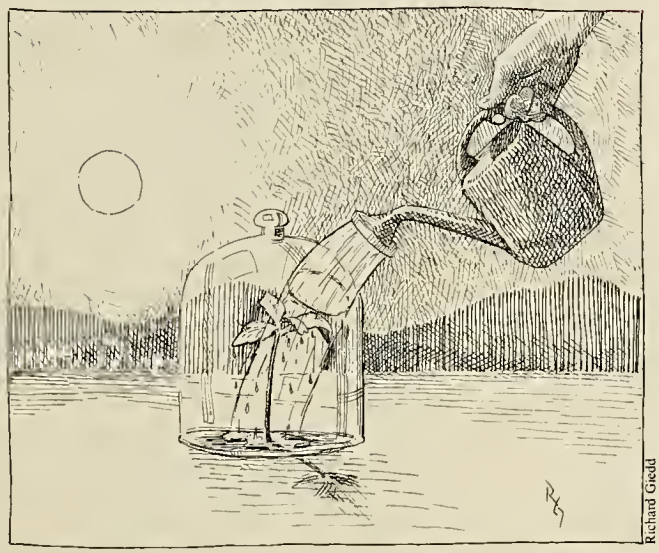
This section, produced under the guidance of the editors of all the Consortium magazines, is printed in each of those six publications. In other words, through the core, the words and ideas of WPI's faculty, students, alumni, and administration regularly reach about 250,000 readers. We work hard to ensure that the core carries a strong WPI presence in its content.

Another thing that will not change is WPI's commitment to bringing you an excellent magazine, one that reflects the high quality of the institution on which it reports. Any comments and suggestions aimed at helping us achieve this objective will be most welcome.

Donald Berth is vice president for university relations.

COMMUNIQUÉ

Encouraging Innovation at WPI


Richard Giedd

By Dr. Jon C. Strauss

WPI, by virtue of the WPI Plan, is known as one of the most innovative colleges of engineering, science, and management. One of the best things about the Plan is that it is innovative for the right reason: It produces superior graduates. An unfortunate side effect, however, is that it takes so much energy to sustain the Plan that our faculty have not been as innovative as they should be in other aspects of education.

William R. Grogan, dean of undergraduate studies; Richard H. Gallagher, provost; and I view developing a climate conducive to innovation as one of the greatest challenges facing WPI today. Fortunately, we are joined in the observation by a significant proportion of our faculty.

Innovation is particularly important to WPI because it provides the foundation for effective engineering design and entrepreneurship. Because innovativeness can probably not be taught, but can be emulated, our graduates are more likely to be innovative in their professional practice if they emulate the innovation they experienced in the classroom. And if the faculty is striving to be innovative, its members will almost certainly be more effective teachers because their enthusiasm will be contagious.

Although colleges are considered by many to be the change agents of our society, they are normally, by nature and tradition, very conservative. Richard M. Cyert, president of Carnegie-Mellon University, notes several factors that hinder innovation in higher education:

- Each faculty member is an entrepreneur who is "in business" to deliver services in the classroom and develop a reputation through research in a particular discipline. Disciplines are conservators of a main line of thought, and faculty members may be unwilling to risk criticism from their disciplinary colleagues by being innovative.
- Department heads are evaluated by their faculties on the basis of their success at developing resources. Consequently, they may resist unconventional, and hence innovative, activities that might jeopardize resource allocation.

Thus, the decentralized structure and the inherent conservatism of colleges and the professoriate can discourage innovation.

Given these facts, how can Dick Gallagher, Bill Grogan, and I encourage innovation?

A simple answer is to proclaim innovation as a goal so often that it becomes accepted as a way of institutional life. Beyond mere proclamation, however, we have one major resource at our disposal: the institutional reward system.

We encourage department heads to reward innovation and, if necessary, we intervene directly to provide rewards through our annual salary reviews. And we make certain that innovation is weighed heavily in all tenure and promotion cases.

Moreover, we attempt continually to focus the attention of the faculty and staff on innovation, first by emphasizing its importance in messages such as this one, and then by demonstrating our personal receptivity to innovation, ensuring prompt discussion and timely implementation of new ideas and attempting to be innovative ourselves.

In addition, we have introduced two changes to encourage innovation. These include:

- The Research and Educational Development Councils, which provide seed funding for innovative ideas.
- Our five-year planning process, which stresses innovative planning and behavior. Innovation is best considered part of strategic (long-term) planning, rather than tactical (short-term) annual budgeting.

Two major tasks remain. We must bring to WPI recognition for the innovation, excitement, and quality of our faculty and programs. And we must develop the additional resources necessary to free up faculty time for developing innovative scholarship.

Our ongoing $52.5-million *Campaign for Excellence,* which last fall passed the halfway mark, is focused on the latter task. The new resources we raise will be employed to enhance our extraordinary undergraduate program, to develop further the scholarship of our faculty, and to improve the quality of our facilities. Success in these endeavors will assure the recognition we seek and deserve.

Jon Strauss is president of WPI.

INVESTIGATIONS

Of snakes, fishnets, and polymers

Imagine a trash barrel filled to the brim with snakes. Unable to move freely, the snakes slither through the gaps that open up in the wriggling mass.

Now, imagine a fishnet strung across a pool teeming with fish. While smaller fish pass through the net, the mesh impedes the movement of large fish.

These two analogies form a simplified version of what has been, for more than a decade, the accepted model of how large polymer chains move through solutions. Now, George D.J. Phillies, associate professor of physics, has developed a new theory that challenges this so-called "reptation" model. The theory could benefit industry by helping to predict more accurately how long chemical reactions involving polymers in solution will take.

Phillies' model is based on five years of work with quasi-elastic light-scattering spectroscopy, or QELSS, a technique in which he illuminates a solution with laser light and measures the Doppler shifts caused by the motion of suspended particles. These shifts reveal the velocity of the suspended bodies.

Phillies uses QELSS to monitor the movement of reflective spheres called optical probes as they travel through solutions of various synthetic and biological polymers. By changing the sizes of the spheres and the concentrations of the solutions, Phillies assembled a new picture of polymer movement.

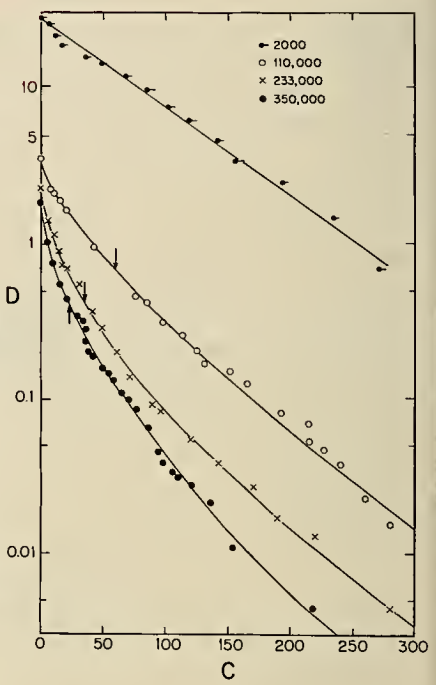
While the reptation theory says polymer solutions should slow large optical probes more than small probes (remember the fish and the fishnet analogy), Phillies found that the solutions are equally effective at slowing large and small spheres.

And, while the reptation model says the length of the polymer chains should not affect the rate of diffusion of a probe, just as the length of the ropes making up a fishnet would not affect the size of the fish it can catch, probes actually diffuse more slowly through long chains than through short chains.

In Phillies' model, polymer chains coil into roughly spherical shapes. Rather than slithering in and about other chains, the coils move like microscopic submarines that create wakes. The wakes affect the motion of nearby chains that, in turn, create echoes of the original wakes. These complicated hydrodynamic interactions are the forces that control rates of diffusion and viscosity in polymer solutions, Phillies says.

In addition to providing a model that is consistent with experimental evidence, both his own and that of other researchers, Phillies' theory can account for the behavior of the entire range of polymer solutions from very diluted to highly concentrated. Reptation, on the other hand, works well only for the middle concentrations.

Phillies' models may stir things up in the biochemical industry. Many modern chemical products are made using catalysts known as enzymes. Relying on the reptation model, chemical engineers have avoided using enzymes in concentrated polymer solutions, since the dense mixture was believed to slow enzymes and limit their effect. Phillies' theory, however, says enzymes should move as rapidly in concentrated as diluted solutions. Using more concentrated solutions may enable engineers to increase the yield of their reactions.



This graph shows the diffusion coefficients of polystyrene chains of different molecular weights compared to a new model of polymer diffusion developed by WPI physics professor George Phillies. The smooth curves show how well the Phillies model accounts for the entire range of polymer solutions, from very dilute to highly concentrated. The data were collected by P.T. Callaghan and D.N. Pinder at Massey University in New Zealand.

The unexpected genetics of fish food

In science, the detours one takes on the road to an answer can often provide the greatest rewards. Such has been the case for Dr. Joseph C. Bagshaw, professor and head of the Department of Biology and Biotechnology.

A few years ago, Bagshaw began searching for clues about how genes are "turned on and off." Along the way, he and his students have discovered a previously unknown genetic mechanism.

Since every cell in an organism, from a bone cell to a brain cell, has exactly the same genetic blueprint in its nucleus, cells must have a mechanism for activating or expressing only the genes that produce the proteins they need, while deactivating the rest, Bagshaw says.

Through a three-year grant from the National Science Foundation, Bagshaw is studying the brine shrimp, a small crustacean sold in pet stores as fish food. The shrimp are obtained as embryos and, when placed in brine, quickly develop

into larvae.

Since the cells in the larvae are quite different from those in the embryo, the brine shrimp may provide clues as to how the cells of an organism, all of which have exactly the same genetic blueprint, can activate only the genes that produce the proteins they need, while deactivating the rest.

As a first step, Bagshaw studied the brine shrimp's messenger RNA. Each messenger RNA, or mRNA, is a template cast from an individual gene; on these templates, proteins are put together.

By comparing the mRNAs of the brine shrimp embryo with those of the more complex larvae, Bagshaw hoped to find clues as to how the developing crustacean turns on "larval genes" and shuts off "embryo genes."

When the mRNAs were analyzed by Bagshaw's research team, including two seniors working on their Major Qualifying Projects, the results were unexpected, even startling.

"It turns out the brine shrimp's mRNA is not routine in its structure," Bagshaw says. "In fact, it's not like anything anybody has ever seen before."

The data showed that only 20 percent of the genetic sequences transcribed into mRNA in the brine shrimp were "unique" genes. The rest contained transcripts of repeated sequences, long stretches of DNA made up of many copies of the same genetic information.

Unlike genes, these sequences do not appear to be transcribed into proteins. Instead, experts believe they regulate the transcription process. In fact, in no other organisms ever studied have so many repeated sequences been transcribed into mRNA, Bagshaw said.

Bagshaw can't yet explain the significance of this finding. It appears, he says, that the brine shrimp employs a different mechanism of genetic expression than other organisms studied to date. Since no other laboratory has examined the genetics of crustaceans in as much detail as Bagshaw's group, only time will tell if this mechanism is common to all members of the phylum.

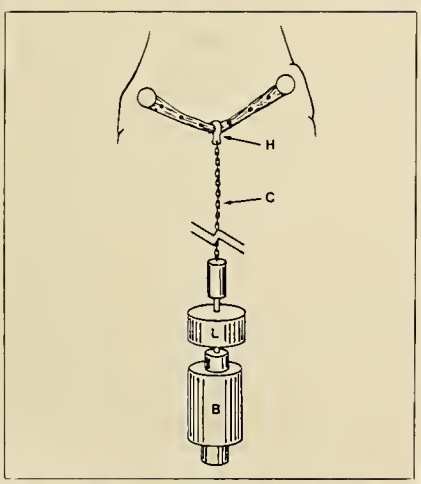
It may be, Bagshaw says, that the method is an ancient one which has survived intact from an early point in the evolution of animals. While other organisms developed more advanced forms of genetic expression, the crustaceans never changed. It may also be a method that developed only in the crustaceans and is therefore unique to that group.

The mechanics of a cat's knee

"A match made in heaven."

That's how Dr. Allen H. Hoffman, professor of mechanical engineering at WPI, describes his collaboration with Peter Grigg, professor of physiology and a National Institutes of Health Jacob Javits Neuroscience Investigator at the University of Massachusetts Medical Center. Over the last 10 years, the two have combined their perspectives as engineer and neuroscientist to develop a unique solution to a long-standing problem. For many years, physiologists who attempted to study the mechanics of soft tissues, such as ligaments and tendons, were faced with a catch-22. The devices one can use to measure loads applied to intact soft tissue in a living animal are more rigid than the tissue itself, and therefore unacceptable. If the tissue is removed and tested in the laboratory, the results are of questionable value, since it cannot be known if they accurately reflect the way the tissue behaves in its natural state.

Hoffman and Grigg's work on this problem began as an attempt to learn more about the sensory neurons in a sheath of soft tissue, known as the capsule, that surrounds the knee joint in cats and many other mammals, including humans. Their aim was to quantify the types of loads that cause these neurons to fire. However, no methodology existed for making this type of study.



This is the apparatus used by Allen Hoffman, WPI professor of mechanical engineering, and Peter Grigg, professor of physiology at the University of Massachusetts Medical Center, to apply loads to a cable-like ligament in the capsule of the cat's knee. The researchers solved a long-standing problem of measuring loads in intact soft tissue.

Their first breakthrough was the discovery that the knee joint capsule of small animals is suspended from a ligament that behaves like a catenary, an engineering term for a suspension cable that sags under its own weight.

This finding allowed Hoffman to create a model that predicts how the shape of the ligament will change as different loads are placed upon it. This model was confirmed experimentally by using an apparatus developed by Grigg to place precise point loads on the capsule ligament.

The model enabled Hoffman, Grigg, and a team of WPI graduate students to look at the shape of the ligament in an intact knee and know precisely the load it was under. From these results, they could also deduce the load experienced by the entire capsule, Hoffman says. The next task fell to Grigg. Using painstaking microsurgical techniques, Grigg isolated individual neurons from among the hundreds of nerve cells found in the top of the knee capsule. The goal was to find only those neurons that were located in the cable-shaped ligament. Once such a neuron was pinpointed, its rate of firing could be calibrated to the load being experienced by the capsule.

Using these calibrated neurons as biological load cells, Hoffman and Grigg moved the knee joint of test animals through the full range of extension and measured the output of the neurons. They discovered that the load on the capsule was much smaller than expected. In fact, contrary to generally accepted thought, the capsule seems to absorb almost none of the loads placed on the knee when it is extended.

"Some of the previous predictions of the stresses on the capsule were based on dissection studies and mathematical models of the knee," Grigg says. "One of the things we showed is that models and cadaver studies can be wrong."

In work now under way, Grigg and Hoffman are looking at the stresses experienced by the capsule when the lower leg is rotated about its long axis. So far, it appears that the capsule may absorb some of the stresses placed on the knee in this type of motion.

They also plan to look at the response of neurons while the cable-shaped ligament is loaded dynamically, work they will do in collaboration with a researcher at the University of Utah.

—Michael Dorsey

INNOVATIONS

Placing a Premium on Good Teaching

"A teacher affects eternity; he can never tell where his influence stops"
—Henry Brooks Adams

"We are bootstrapping ourselves into the modern age," says James S. Demetry '58, professor and associate head of the Electrical Engineering Department, describing the mission of WPI's new Educational Development Council (EDC).

Demetry, chairman of the joint student, administration, and faculty committee that oversees the activities of the EDC, says the goal of the organization is simple: promoting good teaching.

"Teaching is an integral part of the academic profession," Demetry says. "But few of us have any formal training in instruction, and that can be very frustrating."

To help relieve that frustration, the faculty approved the creation of the EDC in 1986, and WPI agreed to provide $75,000 in annual funding.

Among the goals of the EDC, Demetry says, are helping WPI's faculty appreciate the value of good teaching, providing training and remediation for faculty members who require it, and encouraging innovation in the classroom.

So far, the EDC has funded a variety of activities, including the purchase of "The Mechanical Universe . . . and Beyond," a series of 52 half-hour lessons in physics, electrical engineering, and mechanical engineering produced by the Public Broadcasting Service to be used as teaching aids.

The EDC also sponsored on-campus teaching workshops by Lawrence M. Aleamoni, director of the Institute for Educational Research and Development at the University of Arizona. Aleamoni's counsel and other tips on good teaching will be circulated in an occasional publication called *Notes to the Faculty.*

One of the EDC's major tasks, Demetry says, is the presentation of annual grants to faculty members who wish to develop innovative approaches to education.

"Educational innovation is an area where WPI can make a real contribution," Demetry says. "It's important that we support it."

Last fall, the EDC distributed about $60,000 to more than 20 faculty and staff members. The grants included funding for four new courses and the production of several new educational videotapes; projects that will introduce the computer into the classroom and fine-tune the college's writing program; a workshop on advising Interactive Qualifying Projects; a symposium on the teaching of science; a "space forum" for students doing space-related projects and research; and a lecture series on women, minorities, and technology.

"These are all exciting projects," Demetry says. "I think we've taken a major step forward in our efforts to sharpen our edge in stimulating instruction at WPI."

—Michael Dorsey

Correction

Following publication of a story entitled "Room with a View" (*WPI Journal*, Summer 1987), profiling Alfred A. Molinari '63, additional information about Mr. Molinari's association with his former employer, Analogic Corp., was brought to the attention of WPI officials. Clarification of several issues is in order:

Mr. Molinari claimed that it is common practice for larger companies such as Analogic to discourage entrepreneurship by "squashing new competition" with lawsuits, and that Analogic brought a lawsuit against his new company based upon nebulous claims. The following are the facts of record:

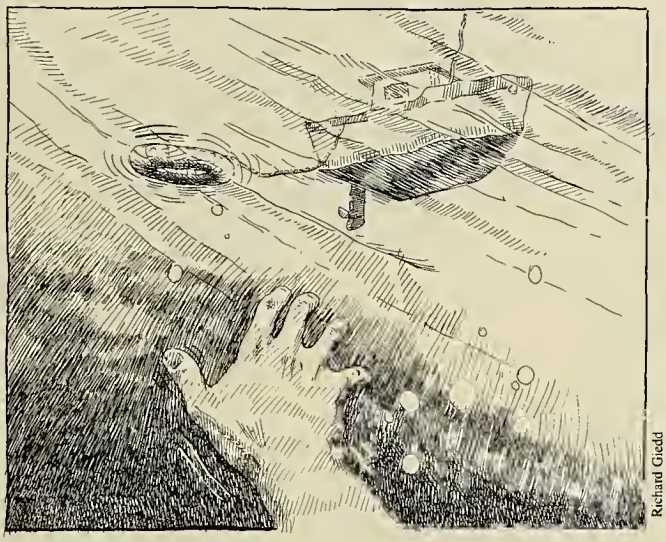
Mr. Molinari lost his case, and on appeal, the Supreme Judicial Court of Massachusetts, in its decision, cited in the case reports of Massachusetts as 371 Mass. 643, said, "The master's report sets out the following findings. Analogic employed the defendants Molinari and Fishman during the development of an unpatented, high-speed data acquisition module. The development of this device consumed some eighteen months and over $100,000. Thereafter Molinari resigned in 1973 at the plaintiff's request. Fishman subsequently left the plaintiff's employ on his own motion. These two defendants then met with the defendant James Neil Forster to form Data Translation, Inc., for the purpose of creating a data acquisition module similar in all respects to that of Analogic. At the time of the departure of Fishman and Molinari from Analogic they signed statements indicating that they were not taking with them any documents or any material belonging to Analogic. However, utilizing documents, drawings, and a sample of the plaintiff's module 'MP 6912,' the defendants were able to create a copy of a module in a few months at a cost of approximately $2,500. They then commenced marketing module DT 1610 at a price comparable to, or less than, that of the 'MP 6912.' The master found that none of the individual defendants was capable of designing such a module in less than one year without use of their special knowledge of the MP 6912,' and that the defendants Molinari and Fishman violated their agreements with the plaintiff in using data and documents belonging to the plaintiff."

Final judgment of the Court ordered Mr. Molinari and the other defendants to pay Analogic money damages and ordered them not to manufacture or sell the product in question for one and a half years, the length of time it would have taken to legitimately copy the product had they done so in the first place.

WPI regrets the implications which the original story may have held for the ethics and integrity of the officers of Analogic Corp.

The Editor

Sink or Swim: Helping Freshmen Succeed



Richard Giedd

By Kenneth McDonnell

Every college has its elite students. But the law of averages dictates that every college class will also include a small group of students who, for one reason or another, find the grade too steep.

From time to time, it is important for a college to ask why the pursuit of an academic degree will, for some, end in failure. Does the cause lie in high school preparation, faculty advising, insufficient remedial attention, or, perhaps, the sink-or-swim attitude of the institution itself?

"We'll always have failures," allows William R. Grogan '46, dean of undergraduate studies. "In such an intensive academic arena, it's inevitable. But, how we respond to this situation—both for the troubled student and for the future student—is crucial."

Last summer, a study group made up of faculty members and administrators compared academically troubled and academically exceptional freshmen from a current class. The group's goal was to find common denominators that can help explain and prevent freshman failures.

"The data we uncovered," says Ann C. Garvin, committee chair and director of academic advising, "reveal the many threads in the fabric of the WPI experience, but no one factor explains the academic difficulties of the freshmen studied."

Still, several of the committee's findings contribute significantly to understanding how to help troubled students.

Starting with the admissions process, the committee could find no evidence to suggest deficiencies in how WPI selects its students. In fact, the class in question was academically very strong.

The committee found, however, that SAT scores are not always accurate predictors of collegiate success; high school class rank and academic achievement test results were better.

"This isn't news to us," says Grogan, "and it validates a nationwide trend to downplay the importance of SATs in the student selection process."

In addition, students who ran into trouble during their first year typically had problems in several subjects. But their difficulty was most evident in mathematics and, to a lesser extent, chemistry. Larger-than-normal class sizes in some math courses and a prevalence of new mathematics faculty members, with different styles of teaching and grading, may have contributed to the situation, the committee reported.

But one fact is plain: 64 percent of students who chose not to repeat a failed math course also failed the next math course they took.

Residential and social factors seemed to have little effect on academic performance. On the other hand, commuting students seemed to fare better, on average, than residential students, and women seemed to find adjusting to college more challenging than their male classmates. Finally, student alcohol problems and family illnesses were clearly linked to several cases of student failure.

"Motivation and discipline may be the most vital ingredients in successfully negotiating the freshman year," says Bill Grogan. This age-old idea sums up his reading of the committee's conclusions.

"The students who worked hard and did well in high school—those who developed good study skills and discipline—are the students who are most likely to make it through the crucial freshman year at WPI," he says.

How can the college help those for whom motivation and discipline are problems? "If anything," Grogan contends, "we've underestimated the importance of prompt and vigorous action in responding to freshmen who develop problems in the fall semester. We need to learn more about how failures may be alleviated through better advising and teaching."

Toward these ends, says Grogan, student life and faculty advisers will watch more diligently for early signs of trouble. Further, the admissions office will place more emphasis on evidence of motivation and perseverance, academic achievement tests, and high school class rank in screening applicants.

In addition, freshmen must now pass each course in the math and chemistry sequences before proceeding.

The committee will continue its study, Grogan says, largely to find ways of helping motivate students to reach their potential. As a step in that direction, WPI will participate in a pilot project of the Noel/Leivitz Centers for Institutional Effectiveness and Innovation. The study will test a psychological inventory that should help WPI measure student motivation and pinpoint students who need extra help—before they fail.

EXPLORATIONS

To Convert, or Not to Convert: That's the Question for Electric Utilities

Interactive Qualifying Project by Raymond R. Labbe '88, Marc R. Moran '88, and Peter E. Nordquist Jr. '88

Advisor: Douglas W. Woods, professor and head, Social Science and Policy Studies Department

In the wake of the oil crises of the 1970s, several New England electric utilities modified the boilers of their oil-burning power plants to enable them to burn coal, a less expensive domestic fuel. In recent years, though, falling oil prices have made it difficult to justify the expense of converting oil plants, and, in fact, no coal conversions are currently on the drawing board in New England.

According to this study, however, coal conversions carry with them a host of benefits that should make them attractive today—and in the long run.

Combining basic economics and computer science, the students first developed a model with which a utility can weigh the economic pros and cons of converting a power plant to coal.

The model takes into account a variety of economic factors related to the cost and benefits of making an investment in coal conversion and weighs these against three possible scenarios for the future price of oil, enabling a utility to determine whether a conversion will make strict economic sense.

In most cases, Labbe, Moran, and Nordquist say, utilities would save money by converting, since forecasts show the price of oil is likely to increase dramatically within five to 10 years. These savings could be passed on to the consumer.

But they also note that there are noneconomic factors that should be considered. For example, coal conversions help to revive the flagging U.S. coal industry and decrease the nation's dependence on foreign oil.

Helping People See the Dangers of Fire

Interactive Qualifying Project by Jan Husby '89, Eric Martin '89, and Matthew G. Mooney '88.

Advisors: Jonathan R. Barnett, associate, Center for Firesafety Studies; and Holly K. Ault, instructor of mechanical engineering.

Each year, fire kills some 6,000 people and causes billions of dollars worth of damage; most of these losses occur in homes and apartments.

To help understand how fires start and spread, scientists use a variety of computer models that can simulate the growth of a room fire, given such factors as the size of the room and the way it is furnished.

However, while these models could prove valuable as educational tools, most display their results in the form of numbers or graphs that may not be easily understood by nonprofessionals.

Therefore, Husby, Martin, and Mooney decided to use the power of computer graphics to make the message of the fire models readily apparent.

They designed a computer program that transforms the output of the Harvard Fire Code, one of the most widely used simulations, into a form that can be easily read by graphics software. With this interface, a user can create a room, ignite a fire, and then watch the way the fire develops.

The students tested the animation program on fire protection engineers, fire fighters, and lay people. They learned that their program does indeed work well as an educational tool, not only for the general public, but for architects and design engineers as well. They also gathered suggestions that will help them make the program easier to use and understand.

Looking for Links Between Science and Art

Interactive Qualifying Project by Patrick Brennan '87, Michael P. Burke '89, Ralph A. Desrosiers '88, and Iakovos A. Iakovou '89.

Advisor: Lance E. Schachterle, chairman, Division of Interdisciplinary Affairs.

Traditionally, science and the arts have been seen as separate, and sometimes conflicting, pursuits. According to this project, however, science and art share a common ground. Artists and writers have often acted as the social conscience for scientists.

Conversely, science has aided the development of the arts by providing tools, such as the printing press, film projector, and computer-animated graphics and film effects.

In recent years, cybernetics—the study of human control functions and of mechanical and electronic systems designed to replace them—has been an intersecting point for science and the arts.

For their project, students analyzed several works of modern fiction, looking for the influence of cybernetics on modern authors.

They found that the subject of cybernetics is sometimes treated in modern literature—especially science fiction—as an integral part of the plot. More subtle is the way authors integrate principles of cybernetics into their works, as when the central characters are called on to solve problems, as a computer would, using feedback or the input of information.

They also looked at the growth of intelligent computers, which are being programmed to write poetry and create works of art that rival works created by people. This fusion of science and art may, they argue, erase the line between these disciplines forever.

—Elizabeth B. Glidden, assistant director of the WPI News Service

The State of the Arts

For many of today's undergraduates, music and drama are among WPI's attractions.

By Amy Zuckerman Overvold

Janet Woodcock

The Wind Ensemble (above) rehearses under the baton of Douglas G. Weeks, director of applied music. Members of the Women's Chorale (right) perform during a Christmas concert for the WPI community.

Louis Curran, director of the WPI Glee Club, recently asked a gifted student musician why he wasn't attending a music conservatory instead of a college of engineering and science.

The young man paused for a moment, then explained that most of his musician friends were either unemployed or playing on street corners. Since he had both artistic and technical abilities, he opted for an engineering career. "That way," he told Curran, "I can support my music."

This story is indicative of the changing WPI student body—one no longer drawn solely from the ranks of budding engineers and scientists.

More and more, students are coming to WPI not just for the quality of its academic programs, but for the proliferation of performing arts programs. The programs are buoyed by a strong Humanities Department and a degree requirement called the Humanities Sufficiency, which gives students the opportunity to explore deeply an area of music or drama, among other areas.

Douglas Weeks, who was appointed in 1987 to the newly created position of administrator of applied music, remembers when all the music programs then on campus—the Brass Choir, Glee Club, Wind Ensemble, Stage Band, and Women's Chorale—operated out of a house on Schussler Road.

That was eight years ago. Since then, Weeks says, interest in music has increased so much that every one of Alden Memorial's practice rooms is booked solid. It's no wonder, with the addition of musical groups like the Woodwind Ensemble, WPI Jazz Band, WPI Jazz Workshop, a saxophone ensemble, a group that plays improvisational jazz, the Baker's Dozen, the Madrigal, and the Medwin String Ensemble. A similar renaissance has taken place in drama. Under the direction of Amherst, Mass., playwright Susan Vick, associate professor of drama and theater, student interest in the theater has blossomed. In addition to fall and spring productions—including *The Sandbox, Twelfth Night, Talley's Folly, A Moon for the Misbegotten,* and *You Can't Take it With You,* Vick now supervises New Voices, a festival of plays written, produced, directed, and performed by students.

Both programs will receive a major boost within a couple of years. By then, Alden Memorial Hall, the nearly 50-year-old auditorium that is home to drama and music at WPI, will undergo an extensive renovation to convert it to a center for the Humanities Department and the performing arts. Included in the plans is the transformation of the main auditorium into a performing arts center, complete with a modern theater and music performance and rehearsal areas.

Doug Weeks' Alden Hall tower office is the first stop on a tour of WPI's performing arts programs. To find Weeks, just follow the strains of horn and woodwind that filter down the stairwell and through the halls of Alden. You'll find him framed by gothic windows and surrounded by music stands and heaps of musical scores. From this perch, Weeks tends to the dozens of students who come and go looking for sheet music, seeking guidance with their rehearsals, or simply stopping by to chat.

A patient, caring man, Weeks takes the interruptions in stride. After all, he notes, such visits are a sign of the success that has marked WPI's musical efforts. As further proof, he points out that about 100 students sang with WPI's vocal groups in the fall of 1987, about 150 played with instrumental groups, and many did both. At least 300 students out of an undergraduate population of about 2,500 enroll each year in music courses and performing organizations.

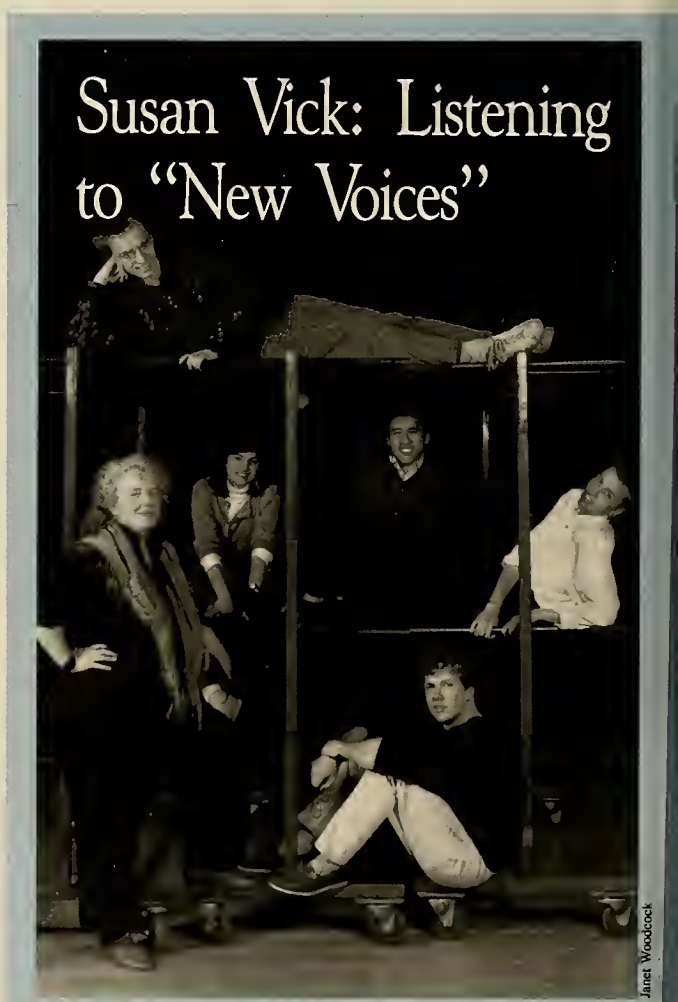
"Music is an important and positive avocation for the students here," he explains. "In spite of their heavy schedules, it's important for them to perform. I have graduate students who have been here six years and are still performing."

Count Linda Blackmar '86 among the loyal performers. Despite a hectic job as a technical writer at Data General Corporation, she still plays French horn in the WPI Brass Choir and Wind Ensemble. Blackmar, who transferred to WPI after attending Oberlin and Nichols colleges, says she wouldn't have come to WPI if there had been no music program.

"Music makes up most of my memories of WPI," she says. "That's where I had most of my fun and where I met my fiancé." She notes that many WPI students remain involved in the arts long after their humanities requirement is fulfilled. "Music is a great way to put your books aside and blow off steam," she says. "It's a productive outlet."

In high school, WPI freshman Thomas Bober, a mathematics major, was an all-Massachusetts trumpet player and occasional professional musician. When he was

Douglas Weeks oversees a growing music performance program that provides a music outlet to a loyal group of more than 200 students a year. "Music is an important and positive avocation for the students here," Weeks says. "In spite of their heavy schedules, it's important for them to perform."



Susan Vick (standing), associate professor of drama, and some of the participants in a recent edition of "New Voices" (left to right, from top: Patrick Brennan '87, Ann Palmer '88, Jason Zee '88, Nancy Teasdale '88, and Jamie Anderson '88.

Janet Woodcock

Not long after arriving at WPI in 1981, Susan Vick, a playwright whose work has been produced in New England and off-Broadway, began fielding questions from students about writing plays.

One student asked Vick if she could write a play for her Humanities Sufficiency. Although privately skeptical, Vick agreed to work with her.

Vick had written her first play at the age of 35, an age suitably ripe for play writing, she says. Could someone so young possess the depth of experience to write plays? she asked herself.

The script turned out to be quite good, Vick says. Then, through word of mouth, other students came her way. "Some of the work was extraordinary," she says.

Before long, she was inundated with new works. "I finally decided that writing was not enough. These kids had to perform so they could see what they had done."

Staged readings led to staged productions, and thus was born New Voices, an annual festival of new works written and produced by undergraduates.

"The program has gone wild," Vick says. "Last year we produced 21 works by WPI students, 125 students performed, 1,200 people saw the plays, and the performances ran for four days."

One of the students whose works have been featured in New Voices is Ann Palmer '88. A slight woman whose small face is framed by dark brown curls, Palmer awed Vick and the WPI community in 1986 with her play *Why Did You Tell Me?*, a frank discussion of adolescent homosexuality. An earlier effort, *Jan Always Taught Me How to Listen,* was also staged in New Voices.

Palmer says the support she has received from Vick and her peers has given her a tremendous boost in morale.

For the moment, Vick serves as a one-person screening committee for the festival. She begins reading scripts in January and soon after starts the search for student actors and directors. Festival time can get a bit frenzied, she says, but adds, "it's worth it."

looking at colleges a year ago, a solid music program was a major concern. Although the rest of the schools on his "wish list" had music programs, Bober says he liked the course selection at WPI and the relaxed mood of its music division.

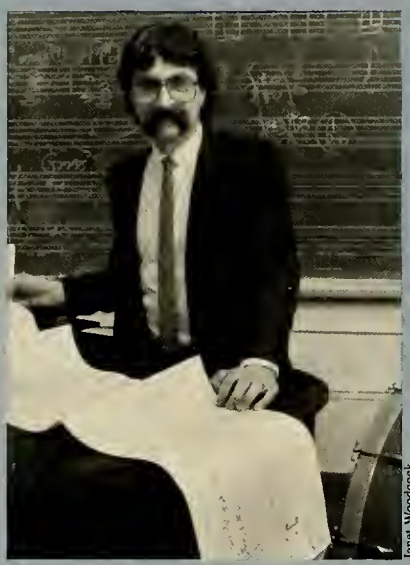
"The conductors and musicians are excellent," he says of the Brass Choir and Jazz Band, with which he performs. "Everyone understands that this is an engineering college with a lot of demands on our time," he notes.

As another school day winds to a close at WPI, the sound of 50 male voices soars majestically through Alden Hall, the deep, rich tones of the young performers blending perfectly as they rehearse a Bach chorale. The Glee Club was one of the first musical groups at WPI, formed when the college was just two years old. Like the musical groups that existed through much of the college's history, it served a largely ceremonial function, Louis Curran says.

When he was hired in the mid-1960s to manage the college's musical efforts, Curran set to work organizing the various musical groups into a formal program. His aim was to have each musical group perform before more and broader audiences. That the performance schedule and student interest have flourished testifies to his dedication and drive. Every year, each vocal and instrumental group performs throughout the Worcester community and on many college campuses. The Jazz Ensemble and Stage Band have performed on television and radio and at jazz festivals. Its members produce a promotional recording each year. The Brass Choir performed at EXPO '86 in Vancouver at the invitation of

WPI's reputation as a center of musical excellence has blossomed, attracting more and more talented musicians to fill the ranks of the growing selection of ensembles.

Richard Falco: Forming a Nucleus for Jazz



Janet Woodcock

Richard Falco, instructor of music, has helped make WPI into the heart of Worcester's jazz community.

"Music is a great way to put your books aside and blow off steam. It's a productive outlet."

Jazz Worcester seemed to burst from nowhere in 1985.

Actually, according to Richard Falco, a Worcester jazz musician who is both an instructor of music and director of WPI's jazz programs, the origin of the now yearly festival goes back many years. Under Falco's direction, the Stage Band and Jazz Ensemble had long been jamming with other area college groups. Then, in 1985, Worcester's jazz community decided to stage a jazz celebration featuring a nationally recognized performer.

Through a grant from the Massachusetts Arts Lottery and the support of the Worcester Cultural Commission, Falco and others created a seven-day festival in collaboration with Clark University, Worcester State College, and other institutions. The likes of vibraphonist Gary Burton and jazz guitarists Ralph Towner and John Abercrombie have performed at WPI and at other locations around Worcester.

The first Jazz Worcester dazzled the community, Falco believes, partly because of the vast selection of jazz offered—from Dixieland to swing to fusion to avant garde. In addition, the festival featured "adjunct art," such as jazz films, poetry and dance, and jazz clinics and workshops.

Jazz Worcester, now in its fourth year, springs back to life for eight days in February 1988. Every Worcester-area college will host performances and, following tradition, WPI will play a major role in sponsoring big-name acts, including Dizzy Gillespie and the Makoto Ozone Quartet.

WPI, Falco notes, has become the unofficial headquarters of the Jazz Worcester Society and the heart of Worcester's jazz community. As the Society's president, Falco says he hopes to extend jazz events throughout the year at WPI and elsewhere.

"If Worcester and New England sense that WPI is wrapped up in jazz," he says, "it's true."

the EXPO Committee.

But the most traveled group by far is the Glee Club. Since the late 1960s, says Curran, the Club has been to Canada, to the West Coast twice, to Europe four times and up and down the East Coast "too many times to count." It has also performed on radio, made recordings, and performed with many top colleges.

With Weeks' arrival and with the support of Humanities Department head Jo Ann Manfra, the program has continued to grow, as have the number of opportunities for students to demonstrate their musical talents. As a result, WPI's reputation as a center of musical excellence has grown, attracting more and more talented musicians to fill the ranks of the growing selection of ensembles.

"One, two, three, now," commands Rich Falco. In an instant, the Wedge is filled with the syncopated rhythms of the Big Band sound as toes start tapping in the audience. The Stage Band is strutting its stuff.

One of WPI's newer musical groups, the Stage Band is an outgrowth of the Jazz Ensemble, also under the direction of Falco, visiting instructor of music and director of all of WPI's jazz efforts.

Jazz is hot at WPI, Falco says. So hot, in fact, that he's had trouble keeping up with students' desires to play improvisationally. But he manages to keep 46 musicians jamming through his two jazz groups and the Jazz Workshop. In addition, he satisfies his and his students' needs for more scholarly work with courses in jazz theory and jazz history, which he has taught for five years.

Falco says it's not surprising that music is such a hit at WPI. He points to a number

of studies that indicate "a definite connection between technically minded people and music," he says.

Malama Robbins, adjunct associate professor of music and director of the Women's Chorale, agrees. "The students tell me that music is very much a part of their lives. It's a continuation of what they love to do.

"Music is harmony, teamwork, performance, outreach, and joy of accomplishment," all necessary components of success in the world, she says.

It's a cold November evening. Students bustle about the stage and the "green room" of Alden Hall, slipping into Victorian-era costumes, gathering props, making final adjustments to a sprawling set of platforms and ramps, testing

Francis Doyle

Director Louis J. Curran Jr., associate professor of music (at the piano), conducts the Men's Glee Club during a concert with the Smith College Glee Club. Curran, who joined WPI in the mid-1960s, organized the college's music groups into a formal music program.

Malama Robbins and the Women's Chorale: No Experience Necessary

Michael Dorsey

The Women's Chorale after winning a silver medal in the Classic Intercollegiate Women's Glee Club Festival-Competition in 1986. Director Malama Robbins (seated at right) founded the group in the mid-1970s.

Even though WPI began admitting women to its undergraduate ranks in 1968, it was several years before a women's musical program sprang up on campus. Women who wanted to sing in a choral group joined the chorus of Anna Maria College, which was then under the direction of Malama Robbins, founder and director of Worcester's acclaimed Salisbury Singers.

In the mid-1970s, WPI agreed to sponsor its own women's choral group at WPI and asked Robbins to be its part-time director. The Women's Chorale was born a few years later.

From a small but dedicated group of women, the Chorale has grown to a 24-member chorus that maintains a busy schedule of performances throughout New England. Two years ago, it won a silver medal in the Intercollegiate Women's Glee Club Festival competition at Molloy College in New York.

As the chorus has grown, so has its reputation, says Robbins, who since 1984 has been an adjunct faculty member at WPI. She says she has fielded invitations to perform from schools as diverse as the U.S. Military Academy and Marist College. The group also performs with the WPI Glee Club.

No experience is necessary to join the Chorale, and Robbins says some women join the group uncertain about their abilities, only to discover they can indeed sing. In recent years, she adds, more and more women are entering WPI who have gained fairly extensive singing experience in high school.

Noting that 10 new freshmen with choral experience joined the ranks, Robbins says that "this year was the best yet."

out a galaxy of stage lights and projection screens. Suspended in the rafters, other students warm up on synthesizer and electronic drums, practicing an irreverent version of "Rule Britannia." The scene is a dress rehearsal for *Cloud 9,* last fall's smash hit and the theater program's latest in a long line of successful productions.

Theater at WPI may not go back as many years as the Institute's musical heritage, but its history is equally colorful. The first known dramatic group, the Tech Dramatic Association, was around as early as 1911. This organization evolved into Masque, which put on its first per-

Janet Woodcock

David McKay: A New Twist to the Art of Making Musi

Give David McKay a Macintosh computer, some speakers, and a synthesizer, and he'll give you back an orchestra. Tell him a humorous story and he's liable to turn it into an opera. Present him with poems and he may put them to music. Show him an organ with a pleasing resonance and he might write some music for it.

McKay, head of WPI's Music Division, is a veritable musical creation machine. In his prolific 32-year career as teacher, composer, musicologist, and musician, McKay has churned out enough music and written material to warrant his own shelf in the Gordon Library.

McKay's experimentation with the computer and synthesizer—his latest interest—stems, in part, from his sense that WPI should stay in tune with the latest technological developments in music. Since its introduction in the early 1980s, he points out, synthesizer technology "has become basic to many music programs."

Synthesizers and computers have also become handy for McKay's own compositions, which lately have included an operatic version of Faulkner's novel *As I Lay Dying,* commissioned by the Society for the Preservation of Southern Culture for performance in 1989.

McKay is also trying to set up a performance of a short "politico-comic" opera about a certain First Lady called *The Arbitrator, or And Your Husband's One, Too.*

McKay has better luck than most composers getting his work performed. *The Yellow Wallpaper,* an opera based on a 19th-century feminist short story—was presented in London by the Academy of St. Martin-in-the-Fields. Another opera, *Bathsheba Spooner,* was commissioned by the American Antiquarian Society and recently performed in Worcester.

But McKay, an Athens, Ga., native, doesn't just compose operas. A true renaissance man, he has 40 or 50 other compositions to his credit, including cantatas, a mass, a requiem, and works for winds, brass, and chorus—even settings for the poems of Stanley Kunitz.

A noted musicologist and specialist in early American music, he is also the co-author of *William Billings of Boston,* winner of the Kinkeldey Award for the best music book of the year in 1975. Moreover, McKay has edited a wide range of Early American music for a variety of publishers. His topics have included colonial band and choral music and colonial opera.

Then there are McKay's four recordings on the Folkways label, all involving early American or 19th-century American music.

David McKay came to WPI in 1956 with a bachelor's degree from Oberlin College and two master's degrees, one from the New England Conservatory and one from Brown University. Until the 1960s, he taught English. Courses in musicology and composition followed.

During his years here, McKay has traveled extensively, lecturing everywhere "from London to Los Angeles. I've lectured at Oxford to the east," he notes, "and UCLA to the west, plus many places in between."

He is particularly fond of the organ and served for 10 years as the organist for the First Unitarian Church in Worcester. One of McKay's favorite concertos is the one he wrote to celebrate the restoration of the famous Hook organ in Worcester's Mechanics Hall.

Although he favors the operatic form, McKay is finding it difficult to work with contemporary subjects that involve copyright restrictions. He is also finding the cost of producing full-scale operas prohibitive and is instead focusing on 20-minute pieces. But whatever he works on, whether it's computers or cantatas, one thing is certain—he'll never lack inspiration.

A scene from Caryl Churchill's* Cloud 9*, a recent production of Masque, WPI's active and innovative student drama group. Susan Vick, associate professor of drama and theater, says it is WPI students and their "passion for the arts" that have made the program the success it is.

formance in 1923 and continues to be WPI's premier dramatic organization. Men played all the women's roles in Masque's productions until 1968, when women started attending the college.

Susan Vick arrived on campus in 1981. Inheriting "a good, but small, group of students," Vick discovered that Alden Hall was providing temporary quarters for the Electrical Engineering Department while renovations to Atwater Kent Laboratories were being completed.

With no practice space or technical support, and with classes to teach and the responsibility to put on two productions a year, she "simply panicked." But Vick had one thing going for her: Lens and Lights, a skilled and dedicated cadre of students interested in the technical aspects of theater. Also, there was Masque, still active after so many years.

Michael Carroll

Composer David McKay, head of WPI's Music Division, has explored a wide range of musical styles, forms, and subjects in his prolific 32-year career. Lately, he has turned his attention to the art of electronic music.

Vick's first production was *Our Town*. She says she chose it because she found it works well in theater-in-the-round. She had already sized up the visual and acoustical limitations of Alden—"the alienating factors" of the hall, she calls them—and decided to place both performance and audience on stage by constructing not only a set, but a theater as well, for each play. Placing the audience on stage also alleviated another concern. Because of the decided technological bent of the student body, she had doubts about the level of interest in theater on campus and dreaded the prospect of her casts playing to a vast, empty auditorium.

As it turned out, the on-stage arrangement worked beautifully, and WPI productions have consistently attracted full houses. "Our largest audience that first year was 125, though *Cloud 9* recently played to a record audience of 233," she says, adding that she has staged her plays in this manner ever since because of her belief that "intimate theater is very important." Vick has found that her dramatic literature classes and the Humanities Sufficiency work in tandem to feed the performing end of the drama program. For example, students read plays in class and ask to perform them. Others attend her classes and are inspired to write or direct a play for their Sufficiencies.

Recently, Ann Palmer and Jason Zee, both seniors majoring in electrical engineering, sat on the edge of the Alden Hall stage and talked about their experiences in the WPI theater program while technicians and actors buzzed around them preparing for a rehearsal.

"Theater is a great release from all my technical work," says Palmer, who has had two of her plays performed as part

"Music is harmony, team-work, performance, outreach, and joy of accomplishment," all necessary components of success.

Michael Mega, second from right, and the Medwin String Ensemble.

Janet Woodcock

Michael Mega: Offering Students an Alternative to Hot Air

Until last summer, music at WPI consisted—literally—of a lot of hot air. For some reason, the college attracted many singers and players of wind instruments, but few players of stringed instruments.

Now, budding violinists, cellists, and bass violin players have an outlet for their talents through the creation of the Medwin String Ensemble. Made possible through a donation of $25,000 by Dr. Herman Medwin '41, the Ensemble performed for the first time last fall.

The group is directed by Michael Mega, co-concertmaster of the Worcester Orchestra, who is actively seeking student players from WPI and other colleges in the Worcester Consortium for Higher Education. When the group reaches satisfactory size, Mega says, he hopes to see the group perform two to three times a year. In the meantime, he plans to expose the students to as much of the classical chamber music repertoire as possible. He wants them to play "everything from baroque to romantic, with possible expansion to the post-romantic and contemporary repertory," he says.

"I want to continue whatever music education these students had in high school," Mega says. "The arts play an invaluable role in rounding out their lives."

"There is a definite connection between technically minded people and music."

of the New Voices festival at WPI and plans to continue writing after graduation, at least as a hobby.

What she cherishes most about the WPI drama program is the fact that it attracts a cross section of the WPI student body. Moreover, both she and Zee say the program is particularly valuable because it introduces WPI's students—many of whom have never attended a live performance—to the theater.

"Drama is tiring, but it can be so rewarding," says Zee, who has profited from semi-professional acting experience in his native Singapore. Although he came to WPI for its engineering programs, the Institute's emphasis on dramatic arts was also important. In 1986, he fulfilled his Sufficiency requirement by directing a production of *A Streetcar Named Desire*.

"It's exciting that a foreigner can get involved in directing a totally American cast in a classic American play," he says, beaming.

In her six years at WPI, Vick has found "extraordinary talent" on campus. "I am much luckier than many of my colleagues in schools with actual theater departments," she says. "The kids here are so talented, intelligent, and motivated. They have a real passion for the arts."

Amy Zuckerman Overvold is a free-lance writer living in Worcester.

PHOTO FINISH

A CONTEST FOR OUR READERS

From a baby's first step to a fall leaf's final hour, what images will you treasure throughout your life?

This is your chance to share your best work. The photo contest's theme is capturing a moment of growth or change. Maybe you caught the smile of a student after graduation, or a scene from the time you learned to snorkle in Corfu. Perhaps it was a moment in your own backyard or while swapping memories at a class reunion. Chances are, many of your finest photos could fit this theme.

Tell us, too, why the moment was special to you and we'll publish the answers along with the winning photos in the August issue.

Prizes

- Two first prizes of $200, one for black & white and one for color
- Additional prizes of $75 for each published photo

Guidelines

- The contest is open only to amateur photographers—those who do not make a living from photography.
- Send no more than five black & white photographs and five color slides or prints. Prints should be no larger than 8″ x 10″ and no smaller than 5″ x 7″.
- All photographs will be returned after the August issue is printed—if you include a stamped, self-addressed envelope.
- Include your name on the back of prints or on the mounting of slides. Include a separate sheet for each entry with your name, address, phone number, and college or university affiliation.
- Please also send a brief statement (25 to 50 words) about why the moment was special to you.
- Photographs can have been taken at any time.

Deadline for submissions: April 1, 1988
Send entries to the magazine, in care of the editor, and marked "photo contest." Questions? Call (301) 338-7904.

Words Apart

Who needs a second language? Americans may—if they want to compete in the new global economy. Or even if they want a little *joie de vivre*.

By Robert Kanigel

Illustrations by Allen Carroll

They are members of the club. Their walls are lined with Cambodian temple rubbings, their book shelves with Paris Métro guides, their scrapbooks with photos of friends they've made in Tuscany or Teheran. Talk to them for long and you're apt to detect a sense of exquisite delight, even a hint of one-upmanship in their ability to navigate through a foreign land or language.

Sally Benckart endures good-hearted ribbing about it from her husband, Jeff. Benckart served in the Peace Corps in Chad, a former French colony in Africa. She had studied French literature in high school and in college, and lived in France for six months. Today, in Boulder, Colo., she maintains so lively an interest in things French that Jeff accuses her of finding that culture and language superior to their own.

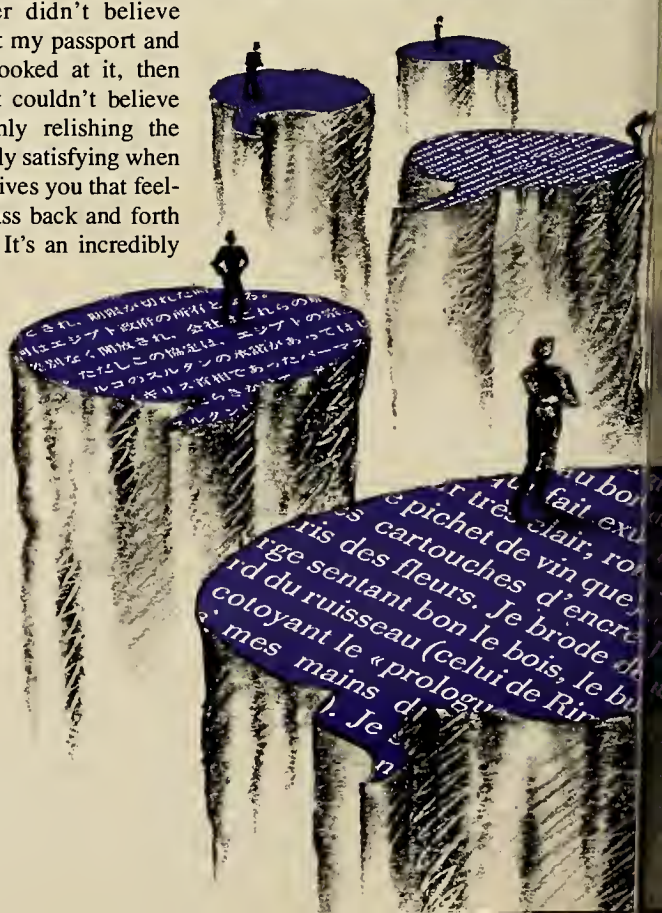
"Oh, I don't, really," says Benckart. "But I do take so much pleasure in it. It's the way physical things, like running, must be for Jeff. Even all the idioms are exciting for me. It's like, not everyone knows what this phrase means."

Other members of the club—diplomats, language teachers, jet-setting executives, scientists, and scholars who have worked or studied abroad—report kindred feelings of quiet satisfaction, knowledge, mastery. Thomas Ricks, a Middle East scholar at Villanova University who is fluent in three languages and able to get by in four more, still remembers the time in Iran, before the revolution, when he struck up a conversation with a Persian soldier while waiting for a bus. Where was he from? the soldier wondered after they'd chatted a while. "Mashhad," replied Ricks, a Peace Corps volunteer who had served in that northeastern Iran city for the past year and a half. "Why, of course," said the soldier. "That explains the trace of Kurdish accent."

When Ricks added that he was an American, the soldier didn't believe him. "I had to pull out my passport and show it to him. He looked at it, then looked at me. He just couldn't believe it," says Ricks, plainly relishing the story. "It's tremendously satisfying when your language ability gives you that feeling of being able to pass back and forth between two cultures. It's an incredibly exhilarating feeling."

Fluency becomes a passport between cultures, even when English dominates the world.

Pleasure? Exhilaration? These are not among the gritty, no-nonsense virtues of language learning that the foreign language lobby cites when it pitches Congress for money for summer institutes and the like. There *is* a language lobby, as a matter of fact—some 30 organizations banded together as the National Council for Languages and International Studies, with offices a few blocks from the Capitol in Washing-



ton, D.C. The council holds workshops, monitors legislation, publicizes horror stories of American language inadequacy—but talks little of pleasure and exhilaration. "The glories of *Don Quixote* are very important for intellectual growth," allows J. David Edwards, the council's executive director. "But they don't help you get along in business."

And it's business, along with foreign policy, defense, and other such practical matters, that Senator Paul Simon had most in mind in his 1980 book, *The Tongue-Tied American*, in which he termed the United States "linguistically malnourished."

By now, after numerous studies and front-line reports from the international trade wars, American foreign language ills make for a familiar litany: How students can earn a doctorate in this country and never study a foreign language. How more people *teach* English in the Soviet Union than *learn* Russian in the United States. How almost one quarter of recently promoted senior Foreign Service officers lacked fluency in any foreign language. How fourth-graders in Botswana get more language instruction than the average American high school graduate, according to a Southern Governors' Association study that termed the United States "internationally illiterate."

David Skelly, a translator for the Library of Congress, recalls how at West Germany's University of Tübingen, where he studied, the Americans were the only group in the polyglot student body who needed remedial German classes. "They were students of German," he emphasizes, "yet they could not speak it." Not long ago, reports Richard Lambert, director of Johns Hopkins University's new National Foreign Language Center in Washington, D.C., a study of language retention conducted by Europeans specifically excluded the United States because American foreign language skills were deemed so low that they would distort the results.

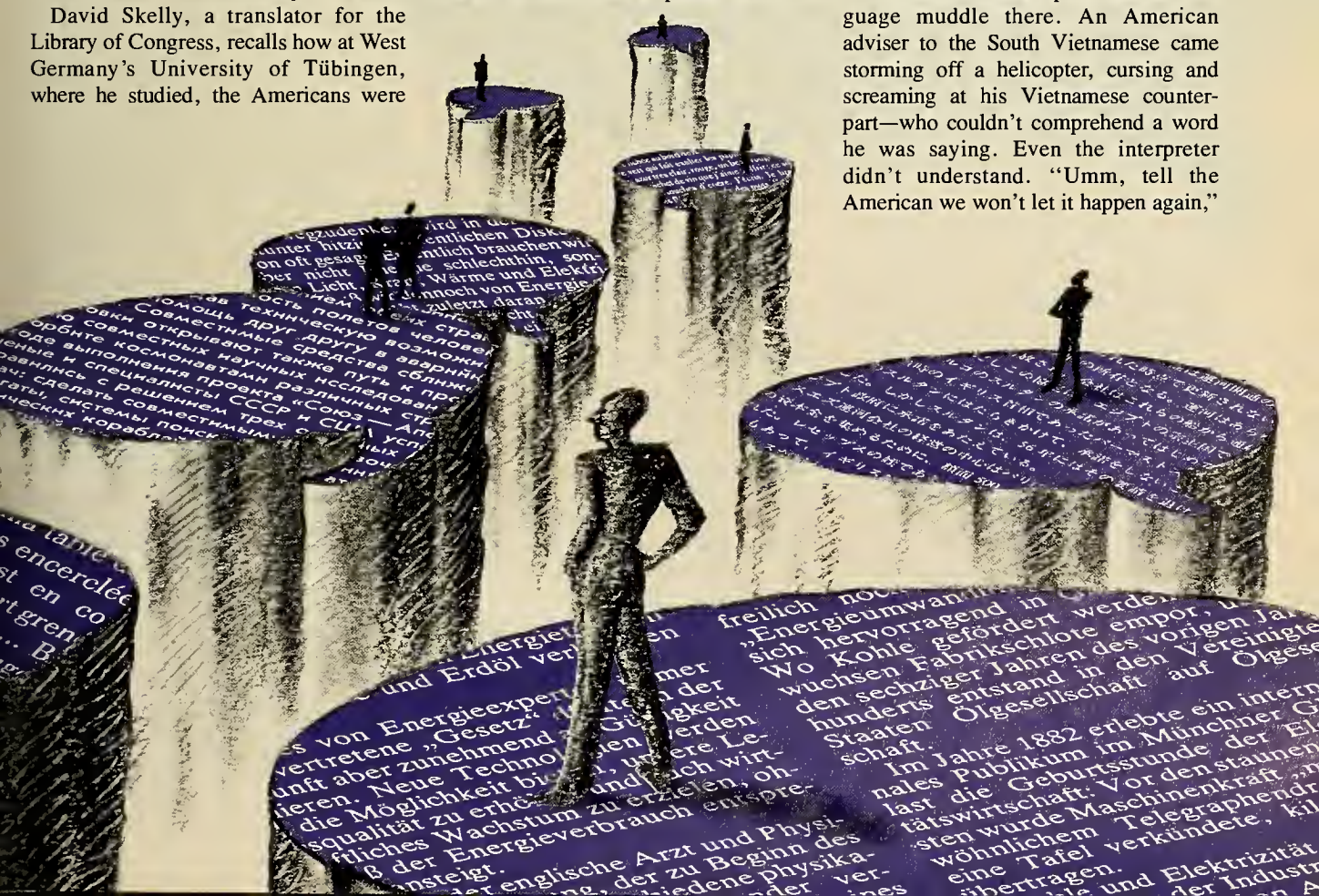
Within the language teaching community, language pratfalls are a source of rich amusement. At a meeting a few years ago of the Association for Asian Studies, Eleanor Jorden, of the Hopkins language center, told how her Asian hotel once mistakenly gave her a wake-up call at 4:30 a.m. instead of at 7:30. "It was a bit unnerving to be awakened at that hour, in the pitch dark, in a strange hotel, still suffering from jet lag," she said. "I jumped up and grabbed the telephone, trying to remember where I was and what I was doing. A voice at the other end announced in English, 'Your hour has come.' "

But other gaffes can bear more serious, dollars-and-cents consequences. As when Chevrolet tried to peddle its Nova in Latin America, apparently unaware that *no va*, in Spanish, means *doesn't go*. Or when Parker, boasting its pens wouldn't embarrass you by leaking, used the Spanish *embarazado* for "embarrassed"—except that *embarazado* means "pregnant."

Life or death can hinge on understanding a word. The head of the Library of Congress's translation unit, Deanna Hammond, tells of how poor Spanish translations of American maintenance manuals contributed to the crashes of several American planes in Latin America. And just before the terrorist attack on the Berlin discotheque in March 1986, U.S. intelligence reportedly intercepted messages from Tripoli to the Libyan People's Bureau in Berlin—but could find no one to translate them.

Senator Simon has argued that American language ignorance may have helped get the United States mired in Vietnam. On the eve of the war, in the State Department and academia combined, fewer than five American-born experts on Southeast Asia could speak those languages fluently, the senator noted. In any case, says Arnold "Skip" Isaacs, author of *Without Honor: Defeat in Vietnam and Cambodia*, language problems contributed to the American defeat.

One incident sums up for him the language muddle there. An American adviser to the South Vietnamese came storming off a helicopter, cursing and screaming at his Vietnamese counterpart—who couldn't comprehend a word he was saying. Even the interpreter didn't understand. "Umm, tell the American we won't let it happen again,"



Enrollments in language courses are way up, in part because the skills are rewarding.

the Vietnamese finally said to the interpreter, who managed to relay that message. The American raged a while longer, finally simmered down, reboarded his helicopter, and zoomed off. The upshot of the story? There is none. The Vietnamese and the American, presumably battlefield allies, went their separate ways, having communicated nothing.

Isaacs, who was a Baltimore *Sun* correspondent in Southeast Asia, learned only about a hundred words of Vietnamese while he was there, enough to haggle with cab drivers and order meals. For reporting news, briefings conducted in English sufficed. But for getting villagers' personal impressions—*How many children have you? What just happened here?*—he had to rely on interpreters. Yet many of them, says Isaacs, could convey only raw facts, with little of the feelings behind them. Often, he sensed a screen between him and what he wanted to know.

Language difficulties so distorted conduct of the war that Vietnamese soldiers who wanted to come into the good graces of the Americans often depended as much on their language skills as on their military ones. "It was very difficult for the Americans to discern who were the good officers among the Vietnamese," says Isaacs. "You'd hear all the time: 'This guy is really intelligent—he speaks excellent English.' "

Stick an American overseas and, the stereotype goes, you get a display of bumbling bluster right out of *The Ugly American*, the 1958 novel. Deanna Hammond tells of a prominent American who, blissfully ignorant of so much as a word of French, promptly got arrested in the Paris Métro. Turns out he sat in a first-class car, but had only a second-class ticket. A gendarme politely asked him to move to a second-class car. The American didn't understand, grew argumentative, began hollering away in English—and was hauled off.

"For a simple thing like that, just a few words would have been enough," laments Hammond. The American couldn't even say "*I'm sorry*" in French.

The Daily Californian was how a Berkeley newspaper had been known since its founding in 1871. But on November 25, 1986, it bore a new masthead—*El Diario Californiano*. The name change served

as an editorial, protesting the passage of Proposition 63, which made English the "official" language of California.

Proposition 63 was the state's reaction to its growing Asian and Hispanic minorities, to how one could take a driver's test entirely in Chinese, or apply for welfare entirely in Spanish. And it expressed a mainstream attitude against foreign cultures and languages that goes far back in America—an attitude H.L. Mencken satirized when he declared, "If English was good enough for Jesus Christ, it's good enough for me."

In his Farewell Address, George Washington warned his compatriots against alliances with the corrupt nations of Europe and against "the insidious wiles of foreign influence." American geography helps to reinforce the insularity rooted in American history. Even today, in the wake of immigrant influxes from Latin America, the Caribbean, and Asia, it is probably still possible to drive the 3,000 miles across the United States yet never encounter a road sign, sales clerk, newspaper, or radio broadcast in a language other than English.

Moreover, around the world, centuries of British colonialism and, more recently, American superpower influence, have made English almost as universal as the founders of Esperanto could have hoped their invented language would be. An Italian pilot, landing an Italian jet in Rome, communicates with the Italian air-traffic controller in English; as *The Story of English* pointed out, it's the language of the skies around the world. Since the 1960s, French is no longer the language of international diplomacy; English is. German, long a requisite of any scientific or engineering student, since World War II has also been displaced by English. Worcester Polytechnic Institute (WPI) Provost H. Richard Gallagher points out that English today is the language of many articles even in German journals. In business, in government, on vacation—almost everywhere, it seems, Americans can get by with only their native tongue.

Edwin Hermann, who for 13 years was an international banker based in Baltimore, recalls getting by fine on English and the little Spanish he picked up in high school and at Western Maryland College, from which he was graduated in 1970. With Europeans, he found, "if you're not comfortable in German or French, they switch over to English." The Latin Americans weren't always so obliging, but banking transactions were usually conducted by telex, anyway, and Hermann could read the Spanish even if he couldn't speak it. "I always feared someone would call who didn't know English at all," he says. "But it didn't happen. Knowing that U.S. people don't speak much Spanish, they'd put someone on the phone who knew English." Meanwhile, he reports, big New York banks with large international divisions would employ a Latin American native or two. "These people were invaluable," he says. "They'd rescue you from a lot of sticky problems."

And so, Americans have been wont to ask, who needs foreign languages? Can we not get by quite well, thank you, without the awful verb endings, the guttural grunts, and all the other linguistic paraphernalia of French and German, Tagalog and Thai?

For years French teacher Sharon Scinicariello, director of foreign language studies at Case Western Reserve University (CWRU), was asked just that by her students. Now she tells them about what happened one day in a Columbus, Ohio, shopping mall. She was sitting at a café, eating lunch, when someone rushed in and cried, "Does anyone here speak French?" Like a doctor whisked to the scene of an accident, she was led to a boy of 9 or 10, an exchange student from France, newly on his own in English with his American host family. The shy, bewildered boy couldn't make known his most basic needs. He understood nothing of what a mall was or why they were there. The family's children were rattling on about *la salle de bain* (they meant *la toilette*), leaving him convinced, says Scinicariello, "that these crazy Americans took baths before going out to a restaurant."

The rolling *r*'s of spoken French resounding through a Midwestern mall are one more sign of America's cultural and linguistic penetration from abroad. By one reckoning, the United States is now the third largest Spanish-speaking country in the world. In New York and Miami, recording studios churn out Latin-tinged pop songs, some of which have begun to reach the charts. In Los Angeles, the number of court sessions requiring translators has doubled in the past five years, to more than 4,000 annually. Universities are increasingly populated by foreigners; almost half of WPI's 360 graduate students hail from abroad, and Hopkins' 1,200 foreign students come from more than 60 countries. Today, cities like Cleveland boast of their sister city status with places like Alexandria in Egypt, Bangalore in India, and Gdansk in Poland. Immigrant-launched Vietnamese, Thai, and Ethiopian restaurants now compete with the Chinese, Italian, and French ones that once cornered the exotic cuisine trade.

The layers of insulation between America and the rest of the world are falling away, the evidence suggests, and "the United States is experiencing," as one writer has put it, "one of its periodic alarms about the paucity of foreign-language study among its youth." Catching the same tide that's begun to revitalize the liberal arts generally, foreign language enrollments are way up. Even Latin is making a comeback. More than 70 colleges and universities have recently added foreign language requirements for admission or graduation. And college teaching positions listed by the Modern Language Association have climbed more than 50 percent in two years. "I don't think interest has ever been higher," says foreign language lobbyist Dave Edwards. What's more, he stresses, this latest surge is welling up from the grass roots, not—as was the case after Sputnik, in the late 1950s—being legislated from on high.

Fueling the shift, of course, are dollars—and yen and deutsche marks. The American economy is increasingly stitched into the world economy. This fall's volatile shifts in the New York Stock Exchange resonated with those in Tokyo, Hong Kong, and Frankfurt. The streets of Detroit are lined with Toyotas from Nagoya and Mercedes from Stuttgart. The Japanese buy up prime Manhattan real estate and Korean immigrants buy out local mom-and-pop stores. The price of wheat in South Dakota rises or

falls with the latest crisis in the Persian Gulf or power shift in Moscow.

"One of the reasons we can't sell agricultural products (abroad) is that we can't deal with them on their own cultural and language levels," former South Dakota Governor William Janklow told editors of the Sioux Falls *Argus Leader* a few years ago. Farmers, he said, had as much reason to learn foreign languages as city slickers. "Would you buy from a guy who came here and spoke Portuguese? Hell no. You want him talking in your language."

American business people have been among the most recalcitrant about applying the maxim that the language of business is the language of the customer. One American executive in Europe, the story goes, could barely utter a *bonjour* after seven years in a French-speaking country; despite a good product, he antagonized his distributors and lost the market to his competitors. More recently, syndicated business columnist Tom Peters, author of *In Search of Excellence*, wrote of being pleasantly surprised on buying a product in quality-conscious Germany and learning it was made in the USA. His pleasure was quashed when he found the assembly instructions written only in English. Imagine, he asked, if a BMW bought in America were to come with an owner's manual only in German.

A few years ago, when Nippon Telephone and Telegraph went abroad for bids for a big contract, the company stipulated that all documents had to be executed in Japanese; not a single American firm applied, reports Dave Edwards. Others have pointed out, moreover, that the Japanese are often in no rush to publish key scientific and technological findings in English—and that information not yet translated remains, though unpatented, as inaccessible to Americans as if it were.

Ironically, it was once the Japanese who were guilty of linguistic and cultural isolationism. In the 1860s, a Japanese visitor to the United States reported back that all single women here were called Joan, while married ladies got the suffix "son," as in Joanson. Nor was it so long ago that the instructions for a Japanese abacus could bear the slogan, "What Brings Comfort and Convenience on Your Life." On their way to becoming a world trading power, of course, the Japanese learned the price they paid for their isolationism. Today some 1,300 English language schools operate in Tokyo alone, and by one estimate, one in 10 Japanese studies English.

Roused by the trade deficit, Americans may at last be learning the Japanese lesson. The National Science Foundation is launching a program to encourage American graduate students and postdocs to study Japanese and, across the nation, Japanese language enrollments are up. Indeed, when Carnegie-Mellon University announced that it would offer Japanese if 10 students signed up, it got 100. CWRU offers three levels of Japanese.

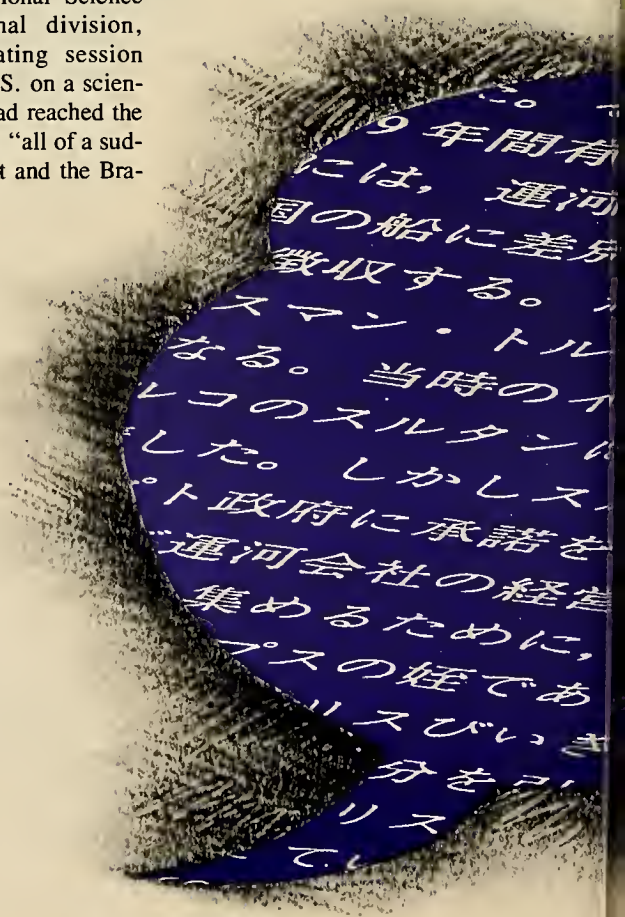
The trade gap with Japan widens—and enrollment in Japanese language programs goes up: a powerful pragmatic streak runs through the American character, a trait noted by observers as far back as Alexis de Tocqueville. The resurgence in foreign languages plainly owes much to this pragmatism. "Never before has there been the economic motivation that exists now for Americans to understand and be knowledgeable about foreign customs and business procedures," said Virginia Governor Gerald L. Baliles, who pointed out that South exported some $54 billion worth of goods in 1984. "It is a lot easier to sell a product if you know something of the customs, language, and background of the customer," he added.

And a lot easier, as Eduardo Feller can attest, to sell your ideas. A science policy adviser with the National Science Foundation's international division, Feller recalls a negotiating session between Brazil and the U.S. on a scientific cooperation pact. It had reached the crossing-of-*t*'s stage when, "all of a sudden, it started falling apart and the Brazilians felt uptight." Feller, born in Bolivia of Austrian parents and fluent in English, Spanish, and French (and with a working knowledge of Italian and Portuguese), thought he knew what the problem was.

In their draft, the Americans had written of "projects," which was translated as *projetos*. Ah, Feller suspected, the Brazilians had concluded that the Americans meant to include only the specific projects already cited, and to exclude others the Brazilians might wish to pursue. In fact, the U.S. negotiators were referring to the projects only to suggest the *types* of work the pact would cover—the broad *project areas*.

"They were talking about different things, using the same word," recalls Feller. "So I shifted into Portuguese and explained it to the Brazilians, then explained it in English to the Americans": It was *programa*, not *projetos*, that the Americans meant. That slight alteration made a difference. Tensions dissipated and the negotiations then proceeded amicably.

Despite the happy conclusion to this story, Feller is no goody-two-shoes internationalist. For him, an intimate understanding of other languages and cultures



Japan paid a price for linguistic isolation. Trade deficits now teach that lesson to Americans, too.

doesn't so much serve world peace and brotherhood as it helps him do his job better. For one, "the other side can't hide behind the difficulty of translation." For another, "you can become empathetic, better understand where people are coming from. You flatter them, lower their guard, then throw them a curve ball." Feller's language skills are a tool—or even, to hear him tell it, a weapon—that give him the negotiating edge.

Foreign language skills do indeed pay—for the job-seeker who can respond to the American Airlines ad recruiting bilingual flight attendants; for the student whose verbal skills, as measured by SAT scores, are apt to rise with study of a foreign language; for the sales executive better able to peddle wares abroad. Language learning, according to a brochure issued by the American Council on the Teaching of Foreign Languages, represents "a sound investment for today . . . and tomorrow."

And that hard-edged, practical message is apparently getting through: "Students see that their clothes are made in Taiwan and their cars are made in Japan," James Gardener, president of Lewis and Clark College in Portland, Ore., told *The New York Times* recently. "They've figured out where the world is moving."

Like most busy professors, Eduardo Gonzalez had let his reading pile build up, and so it wasn't until a day or two after the article appeared in the Baltimore *Sun* that he read it: "Let's NOT Push Language Study" was the headline. Want to learn about Japan or Russia? Well, said the op-ed piece by Reo Christenson, professor of political science at Miami University of Ohio, it's better to read books on Japanese or Russian history and culture than to study those languages. Exposing most students to language study was, he declared, "highly inefficient."

There it was again—that no-nonsense strain in American thought. Indeed, while foreign language enrollments may be up, it's largely out of pragmatic considerations, not broad cultural ones. "I don't see a real change of attitudes," says Peter Lowenberg of Georgetown University's department of linguistics. "The emphasis is not on integrating with the rest of the world, but on competing with the rest of the world, for practical reasons."

Objecting to the narrow, utilitarian tone of Christenson's piece, Gonzalez, associate professor of Italian and Hispanic studies at Hopkins, was moved to write back—in English, a language he learned only after, at age 19, emigrating from Cuba in the wake of the Bay of Pigs invasion. About his reply, published a week later in the *Sun*, he said, "I wanted to defend the notion that language should address, and could alter, a person's intellectual make-up, could alter his sensibilities." There was more to learning a foreign language, in other words, than mere utility.

Of course, liberal educators have long insisted that in some ineffable way, foreign languages "enrich" or "broaden" those who master them. Even President Reagan has said as much, in a proclamation issued last year. Command of foreign languages, he said, "opens up vast areas of knowledge and presents exciting opportunities to understand other cultures. To read classics like Dante's *La Divina Commedia*, Goethe's *Faust*, and Victor Hugo's *Les Misérables* in the original is to gain an insight and appreciation that simply is not possible with even the best translations."

By this broader, less utilitarian outlook, one learns a foreign language for reasons that go deeper than selling widgets to the world—to become more culturally sensitive, more intellectually sophisticated, more alive to complex global issues, and so on. The implication? That the holder of such knowledge thereby absorbs, as Gonzalez put it in his rebuttal, the "values intrinsic to humane and civilized behavior."

But is this just a higher pragmatism, where justification for language learning is seen to lie not so much in getting a better job but in fashioning oneself into a better person? In the service of self-improvement, language learning becomes a duty, like setting aside the summer for *War and Peace*. Is it not enough, one might ask, to speak and read a foreign tongue for the sheer pleasure of doing so, like playing the piano?

If utility were the only valid yardstick, after all, we'd sometimes be left better off—or at least less apprehensive—by not knowing a foreign language. Library of Congress translation chief Deanna Hammond recalls how, on a tour of the Amazon, their group's boat broke down in crossing a river. "No problem," the guide reassured the group of Americans. "We'll have it fixed in a minute." But the moment before, Hammond had overheard the guide turn to a priest and whisper, in Spanish: "God only knows if we'll get back. Pray for us, Father."

Robert Kanigel has struggled to learn French. The Baltimore-based author wrote about chaos theory last May for the Alumni Magazine Consortium.

From Foreign to Fluent: What Works?

Children spend years learning their native tongue. So if you're trying to pick up a new language, be patient, relax, and let it flow over you. Oh, yes—and memorize.

By Robert Kanigel

In French, she never swore, never so much as a *merde*. And when she visits friends and family in France, she still doesn't. Yet in English, her second language, she will occasionally resort to an obscenity. "It doesn't mean anything to me," she explains. "I know it's a swear word, but I have none of the emotions that go with it."

Her name is Brigitte Michel-Heath, and she is a native of France. She has lived in Baltimore for 16 years, holds degrees from a top American liberal arts college and a big state university, has read more Herman Melville and Sinclair Lewis than most Americans, and can wield her accented English with as much finesse as you or I.

Yet an unfamiliar accent, like that of the Chesapeake Bay's Eastern Shore, or an unfamiliar expression, like "to case the joint," can throw her. And the way a slight change of preposition can make meaning abruptly change course—as in *break down*, *break up*, *break in*, *break out*—still drives her batty.

For Michel-Heath, after almost two decades in America, English remains "a borrowed language. It will never be my mother tongue," she says. Every year or two, when she returns home, speaking French again is like taking up where she left off with a best friend. "You wouldn't believe," she says, "what sort of psychic vacation it is." To her, English is still work, though it is no longer, as it was for so many years, *hard* work.

That's what many Americans don't understand about learning foreign languages: You can't expect to learn much from a year or two of it in school.

"The public doesn't know anything about foreign language learning," says Richard Brod, director of special projects with the Modern Language Association (MLA). " 'Fluent' is used so much in a sloppy, ignorant, and uninformed manner." Indeed, the perceived failure of a post-Sputnik federal program that introduced foreign languages into elementary classrooms has been chalked up to just such naïve expectations. Says Michel-Heath, who has taught French in the United States, "American people tend to be so optimistic and unrealistic about learning a foreign language. They think, *I have a French teacher. I will learn by osmosis*. They don't like to memorize."

Back in the 1960s, amidst a rash of wild claims about how one could, in the words of a Sunday magazine article, "Learn a New Language in Five Days," language expert Mario Pei observed: "It is time to stop kidding ourselves about short cuts to *full* language ability." There's nothing wrong with knowing a few stock phrases, he agreed. But recognize that that's just a bare smattering. Real fluency means speaking, understanding, writing, and reading the language pretty much as you would your own.

Even accomplished learners will say that reaching that point is agonizingly difficult. In part, that's because of intellectual hurdles—obscure idioms, grammatical Gordian knots, thousands of new words to learn. Think of the impenetrabilities of English spelling, where the *sh* sound can arise from a dozen letter combinations. But often the difficulty stems not so much from linguistic roadblocks as from the emotional obstacles erected by stepping into another language and culture. You feel confused, inadequate, stupid.

An American auto worker greets her trainer as part of a joint GM-Toyota venture in Japan.

One morning last summer, 19-year-old Lori Clow woke up in a strange bedroom in an unfamiliar house in the south of France. The day before, the Western Maryland College student, with the 12-year-old son of her French professor (Marie-Jo Arey) in tow, had landed in Paris at Charles de Gaulle Airport, maneuvered herself and her charge through the buses and subways, and finally wound up on a train bound for Bordeaux. There she met the family with whom she was to stay for three weeks. The next morning, lying in bed, she at last had time to think. She was armed with little more than high school French and a year's worth in college, and downstairs were five strangers, none of whom spoke English. "What am I doing here?" she asked herself. "I was scared. I knew I'd have to go downstairs and *talk*."

William Durden, who teaches German at The Johns Hopkins University and directs its Center for the Advancement of Academically Talented Youth, was only a little older than Clow when, in 1971, he visited a German-speaking Swiss canton on a Fulbright scholarship. Durden already knew German, or thought he did. But the Swiss, he found, spoke a dialect almost unrecognizable to an ear tuned to stiff High German. His first day, he walked into a bakery and was instantly lost in a sea of alien sounds. "You get so nervous you tend to simply agree. *Yes, yes*, you say." By the time he left, he'd bought so much bread, pounds and pounds of it, that he had to lug it home before he could resume his shopping expedition.

Nancy Rhodes, of the Center for Applied Linguistics in Washington, D.C., once asked the immigrants in her English conversation class whether they had ever, in talking to native Americans, indicated they understood something when they had not. All smiled sheepishly and agreed they had. In a foreign language, says Durden, "you're out of control. And that's a terrifying feeling. Your mind is racing, but all you can do is grunt."

Being lost in a foreign language strips away part of the personal identity you wear like your clothes. "You see it on their faces when they come in here," says Arlene Wergin about the foreign students and faculty members whom she advises at Hopkins. " 'What am I doing here?' their expressions say." For European students, who often know English, it's usually not so bad. But for Hopkins's 80 or so Chinese students, many with poor

Kevin Weber

Mike Sands/CWRU

Fear and confusion often come before comprehension. But the best foreign language students just jump right in.

Costumed as a waiter, Tom Deveny serves up a Spanish lesson at Western Maryland College (left). At Case Western Reserve University, a language laboratory offers practice in the audio-lingual method (above).

English skills, "it's culture shock," says Wergin. "They're extremely reserved, visibly agitated. Or else quiet and withdrawn. They just want to say, 'Please help me. Where is my department? How do I buy food?' "

The saga of immigrants who leave everything behind to start afresh in the New World occupies an honored place in American folklore. Often glossed over, however, is the stress they experience in living and working in a language not their own.

Chan Wook Park, assistant professor of government at Franklin and Marshall College, was one such immigrant. The South Korean native had begun learning English at age 12. In high school, he had taken intensive English classes that sometimes met as often as 10 hours a week. In college, where he studied political science, some of his textbooks were photocopies of English versions. Still, when he came to the University of Iowa as a graduate student five years ago, it all counted for little. He could read *Time* or *Newsweek*, but he'd had little opportunity to speak English; his teachers could hardly speak it themselves. "I did not understand the instructors, and I could not make myself understood." He was touchy, sensitive, and found himself smoking too much. It was a terrible first year.

"Grown man. Sound like child." That was how an eminent Japanese scholar once described to Arlene Wergin how he felt stumbling through English. Yet Wergin has found that it's often a false kindness to ease the way for foreign students and faculty by placing them in the company of their compatriots. "They'll live with other Chinese, or Indians, do their food shopping together. And in the long run it's no help." Yet she understands the appeal such an island of familiarity can hold. "When you have a choice," she says, "you choose the easy way out. It's just easier to hang out with your own." Even for Michel-Heath, the strain of keeping afloat in the English-speaking sea sometimes, over the years, became too great. "I've kept up relationships with people solely because they speak French," she confides, "because they *are* French."

Mario Pei has written about Americans living abroad who mix only with other Americans, confine their reading to English and, even when talking to natives who understand no English, speak it anyway—only more slowly and more loudly. In the end, marvels Pei, they come away wondering why, even after years abroad, more of the language didn't rub off on them. "It would have been a miracle if it had," writes Pei.

We may cluck at the arrogance and foolishness of those Americans. But the formidable forces to which they succumbed are those with which language learners, at any level beyond the most elementary, must always contend. Confusion, exhaustion, and fear are the givens; successful language learners manage to deal with them.

But they don't, for the most part, learn to cope with them in the classroom, which until recently made little room for the emotional realities of learning a foreign language.

Before World War II, there was scant emphasis on getting Americans actually to speak the languages they studied. The dominant approach was the grammar-translation method, with heavy emphasis on literature, language structure, and deciphering individual passages. You could go through a whole course and barely speak a word of the language.

All that changed with the war, when the U.S. government established crash programs to teach Burmese, Japanese, German, and the other languages GIs needed to know. After the war, with America a global power, educators came to realize, says the MLA's Richard Brod, "that we could no longer teach foreign languages as if they were Latin, as if you were never going to speak to a French person."

Along came the audio-lingual approach, inspired by the behaviorist theories of psychologist B.F. Skinner. Learning a language, according to the new wisdom, was like learning to ride a bike; it required the formation of new habits. The teacher would drill students with key phrases, introduce variations, build up to complex dialogues. The emphasis was on developing speech patterns, not on the words themselves. Today, the enthusiasm inspired by that approach is viewed as naïve. And yet, says Richard Lutz, a Georgetown University linguist, he well recalls being in Paris during his junior year of college, wandering from café to café trying to find his way back to the hotel, parroting dialogues he'd learned in school—and marveling that, "strange as it seemed, people could understand me."

The listen-then-speak approach ushered in the era of the language lab with its rows of reel-to-reel recorders and headsets; since then, new technologies have gone in and out of fashion. Today, commercial cassette tapes contain everything from phrase books to entire language learning courses. Some teachers tout video, with its ability to reveal gesture and expression as well as sound. Others, predictably, champion computers. And several colleges, like Bowdoin, use satellite dishes to beam in Russian language programs from the Soviet Union.

While the audio-lingual approach reduced language learning to little more than stimulus-response, the linguistics revolution touched off by Noam Chomsky restored its complexity. For Chomsky, language was innate, the

Bob Stockfield/JHU

In small shops, factories, and schools, immigrants to America have forged new lives. Stress is one price they pay as they struggle to stay afloat in an ocean of English.

human brain a language-constructing instrument. That a child could learn "Mommy" and "sock," then fashion them into some new linguistic entity, like "mommysock," meant, to Chomsky, that language was not just mechanically learned behavior; the child was doing something with, and to, the language. In arguing that the mind of the learner was no mere black box between input and output, Chomsky undermined the basis for the audio-lingual approach and triggered research leading to numerous insights about how people learn second languages.

Among the insights was confirmation that emotional factors, including anxiety and motivation, can indeed inhibit or enhance learning. You may have all the intellectual skills needed to absorb a language, but if your "affective filter" interferes, the intellect never gets its chance.

Another current notion is that if the student can simply listen and absorb at first, without having to spew back responses, she is apt to make better progress in the long run. Such a "silent period," which may range from a few weeks to several months, apparently aids comprehension, which ultimately benefits speaking ability. A young child naturally has that advantage.

A third insight was that language *acquisition*, which takes place through natural communication in realistic situations, differs profoundly from directed language *learning*, which is preoccupied with grammar and other aspects of form. Presiding over this learning is a critical, analytically minded "monitor" (the term was coined by Stephen Krashen, a University of Southern California expert in second languages). This monitor can actually inhibit the natural development of fluency.

Much more has been learned in the three decades since publication of Chomsky's *Syntactic Structures*, but the language classroom has failed to make use of much of it, at least not to the extent of supplanting the audio-lingual method with any single, universally accepted, "best" approach. Rather, a multitude of approaches are in use today. A recent U.S. Department of Education survey listed no fewer than eight. For example, in the total physical response method, students act out commands issued by the teacher. The communicative approach takes emphasis off linguistic forms and puts it on real communication with the listener. Then there are the direct method, the silent way, community-language learning, and something called "Suggestopedia," along with the old grammar-translation and audio-lingual standbys.

Suggestopedia, developed by Bulgarian psychiatrist Georgi Lozanov, is one method aiming squarely at the emotional hurdles of learning a language. The teacher might read a dialogue while students sit back and listen as baroque music plays softly in the background. Apparently the method works well enough to impress even skeptical American observers. Tom Deveny, chairman of foreign languages at Western Maryland College, has introduced elements of the approach to his Spanish classes—with mixed success. Some students like it. Others fall asleep.

For some years, Deveny has also employed a toned-down version of the method pioneered by Dartmouth professor John Rassias, where a master teacher uses every trick of the actor's trade to shatter the emotional barriers of the student. Rassias first developed his method with Peace Corps recruits. Back when she was one of them, former Hopkins nurse Sally Benckart once watched him in action. "He was a very gentle man, but he'd bark rapid phrases at you two inches from your face, to make you respond before you could think." In a Rassias German class, the ghost of Faust might suddenly appear at the door and ask, in German, for sanctuary from the devil. In a Rassias French class, the teacher might crack an egg over the student's head; forever after, presumably, you know what *oeuf* means.

Deveny reports being pleased with his modified Rassias classes. And studies by the Goethe Institute and others have found, as one University of Florida German professor writes, that Rassias veterans "are far more at ease in the language than traditionally taught students." On the other hand, most methods can point to successes. One study of the total physical response method, for example, found that it produced better listening comprehension of German in one-fifth the time of a regular college course. Even the old grammar-translation approach still has its champions, and a study years ago actually showed it could hold its own with other methods, at least over a long enough course of instruction.

Research has failed to crown any one method as superior. Indeed, the lack of a solid research footing in language instruction led Hopkins last May to launch the National Foreign Language Center; one of its goals is to address that failing. In the *Modern Language Journal*, center director Richard Lambert

wrote of the "surprisingly weak tradition of empiricism in the search for what works and what does not work. In place of solidly grounded practice, we have wildly exaggerated claims."

Douglas McNeal, a policy analyst with the National Science Foundation's division of international programs, declares unabashedly that when it comes to learning languages, "some people have it and some don't," a sentiment shared by many in the foreign language community. But sheer language aptitude (of the sort measured on standardized tests) and even raw intelligence apparently play only a small part in determining who will succeed. Personal learning strategies, and personality itself, seem to be more important. When you ask Arlene Wergin, who has seen hundreds of foreign students come through her office, to describe the good language learners among them, she replies unhesitatingly: "They are naturally gregarious and outgoing. They enjoy interactions. They're not afraid to make fools of themselves. They are people who just barrel ahead."

She could have been describing McNeal.

Twenty years ago, he was among an early group of Peace Corps volunteers to go to Korea to teach English. While still in the States, his group got five hours of language training every day. "We memorized little talks: 'Please help me. I don't speak Korean. But I want to learn.' "

Except for its phonetic alphabet (whose standardization 500 years ago is still celebrated as a Korean national holiday), the language is extremely difficult. As in Japanese, the relative status of speaker and listener governs the forms of speech. A GI learning Korean in the bars of Seoul might use one of the two lower forms. In the Peace Corps, they learned only the upper two.

So after three months, though finishing near the top of his class, McNeal still had only a 1+ rating on the Foreign Service Institute's 0-to-5 scale, where 0 represents total ignorance, and 5 means you could be taken for an educated native speaker. Still, as he describes his proficiency at the time, "You don't know much, but you know enough. You can speak all day and all night."

And that, apparently, is what he did on arriving in Korea. For two years he lived with a Korean family in a small town. The family had five children, "so I could pick it up at any level." After another year based in Seoul, he left the Peace Corps at the 3-level. Entering training to become an interpreter, he was soon at the coveted 4-level, lacking only a native accent and a native's rootedness in Korean culture.

At age 28, McNeal began learning Japanese. Seven years later, he took on Chinese. Though he ranks it as easier than Korean, he found it "as hard, at 35, as Korean was at 22." Now, in his early 40s, he says, smiling, "I'm an old man. I'm not going to learn any more of these hard languages." But along the way, he's learned something about *how* to learn languages. And here's some of his advice:

- "What you need to learn most is all around you. It's best just to ask." It might take 10 encounters with a word before it sinks in. But you're apt to pick up everyday words the first time—because they are *useful*. His rule of thumb? "If it's not bumping up against me, it's probably not very important."
- The worst way to understand what's being said is to try to grasp hold of every word as it hurtles past you. Doesn't work, he says. As soon as you hit the first unfamiliar phrase, you start to go under. So just let the words "flow over you."
- Cultivate "a tolerance for ambiguity." Using a new language means living amid perpetual uncertainty, never quite knowing what's going on. "You have to be willing to relax and absorb the larger context."
- Go easy on yourself. You may have all manner of verbal nuances available to you in English. But you must accept that you can't express them yet in your new language. Imagine a funnel: Your thoughts fill the wide end but, to get out, must pass through the constricted neck, which represents what you're able to express. So look for simple ways to convey complex notions. You think, "Had I learned mechanical drawing . . . ." You say instead, "If I could draw . . . ."

McNeal's is just one person's experience. Yet the lessons he draws from it seem to mesh with those of others who have successfully piloted through the thick fogs of an alien milieu. Indeed, for all the disagreement about how best to *teach* foreign languages, shift the focus to how people *learn* them and you find the same few principles cropping up again and again, often reflecting an emotional wisdom rather than intellectual skills.

The foremost lesson is to *interact* with the language. You don't learn a language passively; you have to go out to it. Kids in the Netherlands who routinely hear German TV do not learn German, notes Georgetown's Richard Lutz. Spend a few

William H. Shoemaker (both)

Travelers marvel at how easily a foreign child masters a difficult dialect. But from birth, a child is surrounded by a language's sounds.

months in Europe and will you pick up the language? Maybe yes, maybe no. "It takes courage and a spirit of adventure to enter the marketplace, mingle with the natives, listen to them, mimic them, ultimately speak with them," Mario Pei has written. Not everyone can do it.

Few other academic disciplines demand such a casting away of inhibitions. In most other areas of learning, students are well advised to think out beforehand what the answer is and then, when sure, supply it. Math, science, history, literature—all profit from careful, reasoned thought rather than stabs in the dark.

But that's just the wrong way to learn a language. Former Baltimore *Sun* foreign correspondent Arnold Isaacs tells of once asking the archbishop of Guatemala City, at a press conference following his release by kidnappers, whether he was *casado* after his ordeal. Wrong. He meant *cansado*, "tired." Instead, he had asked the archbishop whether he was married, inspiring a flurry of laughs. "You're guessing all the time," says Nancy Rhodes. The student of language who tries to learn without erring won't. Making mistakes, lots of them, is essential. So is laughing them off.

Even well into the learning of a language, tolerance for one's own limits helps. Hopkins's William Durden notes that on returning to Germany after a long time away, it takes him four weeks to regain his fluency. In the meantime, "You have to cut off forms of conversation you'd normally use," until the old fluidity, the old instincts, are back.

Students new to a language, observes Case Western Reserve University's Sharon Scinicariello, will often try to listen for every word. Instead, go for the gist, the director of foreign language studies advises. A TV newscast offers good practice, because behind the clutter of words in each story is some irreducible essence. Stephen Krashen at Southern California has concluded that emphasis on meaning—what is the other person really *getting at*?—is a better conduit to language mastery than are the words themselves.

As for vocabulary, says Douglas McNeal, you do have to master a basic core. But what of the many specialized vocabularies, like those of electronics or law? "You can't learn all the segments simultaneously," he says. "So you have to choose."

Despite a doctorate in Thai and grounding in French, Hindi, and Sanskrit, Georgetown University language expert Ralph Fasold does not rate himself a good learner of spoken language. Getting in the way, he feels, is his tendency toward perfectionism. "I hate to sound like a kid, stumbling around in a foreign language," he says. And yet, anecdote and research agree, it's kids who actually learn languages best.

A child raised on, say, Hindi and English, can usually slip effortlessly between the two. In fact, the evidence seems to suggest that achieving a native's pronunciation demands learning the language before adolescence. "You've got to learn to roll your *r's* before the age of 10 or you're not going to learn it," notes one language authority.

The extraordinary language skills of children have been variously attributed to their more plastic brains, less dominated by one hemisphere or the other; to "ego permeability" that permits language to reach them more readily; to freedom from adult inhibitions. Another factor, suggests Krashen, is that children and adults inhabit different language environments; in speaking to kids, we use simpler words and stick closer to here-and-now specifics. Both factors make comprehension easier.

And yet, seen another way, there may be nothing so extraordinary at all about the linguistic ability of children. After all, they begin absorbing language the day they are born. As Case Reserve's Scinicariello notes, "They're in it as long as they're awake." The five-year-old Parisian kid who speaks perfect French? Why, he's already spent perhaps 18,000 hours in the intimate company of the French language, points out Eleanor Jorden of the Hopkins language center. All that time, he's been bathed in its sounds, its grammar, its idioms. That's "total immersion" with a vengeance.

The MLA's Richard Brod notes that even five years of a total immersion class—say for six hours a day, five days a week—would grant far less exposure to the language over the same time. How, he asks, can we expect anything from a three-credit college language course that might add up to 100 classroom hours in a year? Should we be surprised that Americans can speak and understand so little when they squeeze French class between band practice, physics lab, and gym? No, he and others insist, the even-the-five-year-olds-can-speak-it argument, far from proving how easy language learning ought to be, suggests how hard it really is.

In "contact time"—that is, the hours spent actually learning the language—Georgetown's Lutz sees "all the variables start tying together" to explain the range of successes and failures in language learning. In other words, put in

enough time and, method-schmethod, you'll learn.

One roadblock to learning a language, after all, is vocabulary. Learn all the grammar, verb endings, and linguistic patterns you like, but without words, you can't communicate. A cultivated speaker can know 30,000 words. And the only way to learn them is . . . to learn them. "It takes lots of memorizing," says the Library of Congress's Deanna Hammond. Studying Spanish in college, she spent hour after hour in the language lab. When she tackled German, picking up credit for two years of course work in eight weeks, she was in class for eight hours a day. Then she'd go home and memorize 100 words a night.

William Durden remembers going out of his way to talk to Swiss shopkeepers, timing his visits to avoid the busiest shopping hours so they'd have the patience for his fumbling. Any departures he noted from his schoolbook German he would record in his notebook. "You have to take a deliberate approach," he says. "The time will come when one morning you wake up and you can have a conversation without thinking about it. But that moment doesn't come from just speaking the language. It comes from studying it."

And it comes from *wanting* to learn it; motivation counts. Georgetown's Ralph Fasold tells of a town in Austria—bilingual in German and Hungarian for 100 years—where Hungarian today shows signs of dying out. In recent years, it seems, Hungarian has become associated with peasant life, German with progress. "I'm not a farmer who picks potatoes and shovels cow crap" is how Fasold interprets the language decisions the townspeople are making. Similar forces, he reports, have replaced Gaelic with English in a much-studied Scottish fishing community, and have kept New Yorkers from learning Puerto Rican Spanish.

But while it helps to be motivated and to work hard, the inescapable truth is that, no matter how hard you work at learning a foreign language and penetrating a foreign culture, you never really *get there*. Even in one's mother tongue that's true. We can't know the language of ballet *and* the jargon of immunology *and* the special slang of the underworld. Nor can we all be poets or gifted public speakers. In a foreign language, much more remains out of reach.

When she first came to the Library of Congress, Deanna Hammond found it humbling that, after years of studying Spanish and living in Mexico, Colombia, and Ecuador, she could not express basic legal terms in Spanish. After three and a half years outside the U.S., her English also had holes in it. "What in hell is a 'hang-up?' " she remembers thinking. "What's a 'flip-top can?' "

Beyond the specialized and shifting vocabularies of a second language, what makes learning it a lifetime's work is that the words themselves become hopelessly enmeshed in culture. Once, "culture" meant art, literature, music. Today, within the language teaching community, it encompasses what one U.S. Department of Education report terms the "sociolinguistic factors influencing what is proper to say to whom, under what circumstances, with which emotional overtones, and with what nonverbal behavior."

Japan presents particular obstacles to Americans, notes Eleanor Jorden, the originator of methods for teaching Japanese that include a strong cultural component. In Japanese, a simple question like "Have you had lunch?" requires knowing the position, status, and gender of all parties listening. An American boss solicited for advice on something you've written, Jorden notes, "might reply, 'I hear what you're saying, but I disagree with you.'" In Japanese, that comment would earn scorn for its boorishness. More appropriate would be a meandering linguistic peregrination from the boss that culminates in something like "While others might well write it in just the way you have, I might conceivably write it this way." The Japanese employee gets the message: He'd better change his version. Such are the cultural roadblocks that non-natives encounter again and again. Hammond, all through her travels in South America, found it was never enough to be grammatically and syntactically correct; how you express joy, or offer condolences, or recognize sarcasm depends on the particular culture. Says Hammond, "All the things I thought were true everywhere, I found, were not."

Tourists encounter culture shock, of course, within moments of arriving in a foreign country. But some scholars have identified a "second wave" of culture shock, where an already accomplished user of the language begins to run up against false turns and roadblocks not evident at first. The result, write William R. Acton and Judith Walker de Felix in *Culture Bound*, is a kind of "'permanent immigrant' state, where one is always able to understand the words but is never completely capable of comprehending all of their connotations."

This higher, cultural plane, as Georgetown's Peter Lowenberg notes, may offer "one of the best buffers against ethnocentrism and chauvinistic myopia." But it is also the final, and almost insurmountable, barrier to learning a foreign language. This is the nether world, beyond words, where the gesture of touching the tips of one's index finger to the thumb, which in the United States means "okay" or "good going," in Brazil becomes obscene. Where to translate the Soviet U.N. delegate's speech may require appreciation of Russian proverbs and nursery rhymes. Where the easygoing American "How are you?" must not be taken as an invitation to recite your most intimate feelings. This is the cultural chasm that remains even once the purely linguistic one has been bridged.

When political scientist Chan Wook Park first taught classes at Iowa five years ago, some of his students complained about his thick, Korean-accented pronunciation. Among other problems, he couldn't distinguish the long *e* from the short, and mentioning an "evaluation sheet" was apt to provoke titters from the class.

But after two semesters, and help from American friends, Park's English improved. A turning point came when he had to deliver a formal, hour-long lecture to an auditorium packed with 500 people. He prepared for it carefully. "My colleagues praised my performance," he says.

Today Park speaks clearly and writes well. The word order of English, which once seemed bizarre to him, now is largely a solved problem, and he has a good position teaching at F&M.

And yet, he admits, "I still have difficulties." One is slang. Another is Johnny Carson.

He listens intently as the star of the *Tonight Show* steps through the curtain and begins his opening monologue. Carson's sly throwaway lines provoke uproarious laughter from the studio audience and in millions of homes across America. Park listens to every word, understands every word. And never laughs.

Translators, Traitors, Transcreators

In an imperfect art, they search for the spirit of a literary work.

By Julia Ridgely

The tourist in the town market flips through a pocket dictionary, trying to find the words that will allow her to buy lunch. The student abroad struggles with unfamiliar syntax, painfully forming what to him seem like backward sentences. The diplomat tries to untangle the subtleties of culture and social status. But beyond all these on the linguistic scale is the literary translator, who must transform novels and poems, essays and folktales, into foreign languages, preserving their unique qualities—style, imagery, humor, rhyme.

Doing the job perfectly, translators admit, is impossible; yet doing it well is essential. Antiquated, or just plain bad, translations can be blamed for turning readers off everything from Homer to Proust. But the pleasure of reading is not all that's lost through inferior translation. Foreign literature is being used increasingly as a way to help fill Americans' need to understand other cultures, particularly non-European ones.

Literature in the college curriculum "used to be limited to the European scene, especially British and American," says P. K. Saha, head of the graduate English studies program at Case Western Reserve University (CWRU). "More and more, given the kind of world we face today, a lot of serious scholars are saying we need to broaden our horizons," he says. Saha teaches his own translations of Bengali poetry as part of a course in non-Western literature.

The responsibility given to translators is enormous, and the frustration can be, too, considering that the result will seldom satisfy the translator or the reader. No matter how good the translation, it's just not the same, as readers are sometimes told rather haughtily by foreign-language-speaking friends. "It's carrying a cross," says Mark Harman, assistant professor of German at Franklin and Marshall College (F&M). "It's not the fault of translators that things get lost; it's the whole sociocultural context." Foreign literature "gets read with completely different suppositions. We're aware it's an imperfect art," he says.

Embarking on a translation means, first and most obviously, having a strong sense of a work's basic meaning—one that fits the author's, not the translator's, intentions. Peter Salm, professor emeritus of German at CWRU, translated Goethe's *Faust* for Bantam Books; he says that a translation "should not explicate, but it certainly must interpret. You

350 years of the *Iliad* in English

Dozens of distinguished translators have tried their hand at Homer's epic. On this and the next page are the opening lines of versions of the Greek poem written some 2,800 years ago.

Achilles' banefull wrath resound, O Goddesse, that imposd
Infinite sorrowes on the Greekes, and many brave soules losd
From breasts Heroique—sent them farre, to that invisible cave
That no light comforts; and their lims to dogs and vultures gave.
George Chapman, 1598

O Goddess sing what woe the discontent
Of Thetis *Son brought to the* Greeks; *what souls*
Of Heroes *down to* Erebus *it sent,*
Leaving their Bodies unto Dogs and Fowls . . .
Thomas Hobbes, 1677

Achilles' wrath, to Greece the direful spring
Of woes unnumber'd, heavenly Goddess, sing!
That wrath which hurl'd to Pluto's gloomy reign
The souls of mighty chiefs untimely slain:
Whose limbs, unburied on the naked shore,
Devouring dogs and hungry vultures tore . . .
Alexander Pope, 1715

have to come up with one interpretation, and then you're stuck with it. In class, a teacher can say, 'It could be this or that,' but not a translator."

Many translators begin with a basic, word-for-word version, then revise for subtlety of meaning, style, and rhythm. Harman, who has translated stories by the contemporary Swiss writer Robert Wälser, says his first step in translating is to read aloud the original: "When I'm done, I read my English version aloud. I tend to begin with a more literal version and move away from it." The process involves compromise between the author and the translator. Literal meaning may be sacrificed to preserve the rhythm of a sentence, or a joke substituted for an untranslatable pun. "If it's a poem for teaching purposes, then I may do as prosaic a translation as possible," says Sarah White, associate professor of French and Italian at F&M. She works with both modern and Old French. "But if it's a poem for publication, then I just wing it. I try to think of English phrases, not words, that do as much as they can. You assume you're going to lose something."

Allegiance, where possible, goes to the author. "If the author has picked that German word because he wants to draw on two or three of the possibilities, I try to find an English word that's not flat," says F&M's Harman. "With a great author who really cares a lot about language, words work on a couple of levels, and the translator has to try to capture this, even though the reader won't necessarily notice."

In spite of such pains, some things will always be beyond translation. Last semester, White taught a fiction class that included a recent Robbe-Grillet novel. Its title—*Jalousie*—means jealousy in French, but is also "a play on those wooden shutters that we used to call jalousies," she says. Thus Robbe-Grillet can use the shutters as a symbol for feelings of jealousy. French readers pick up on the double meaning; English readers never can. In this case, White says, there was no solution but to tip off her students in advance.

In light of such a complex process, the reader's question, "How close is it to the original?" may not be as appropriate as, "Is the experience of reading this in translation like that of reading the original?" A time-honored technique for enhancing the experience is using the language and idioms of the reader. "A prime example was Homer," says J.M. Hunt. "Alexander Pope's translation [first issued in 1715] was titanically popular. He sold subscriptions, which made him fantastically wealthy." But Pope's heroic couplets were far from Homer's language and modern taste. "Homer's Greek is simple and light and fast-moving," says Hunt, associate professor of classical studies at Villanova University. "Pope's style is much more formal. In order to get those rhymes, he has to pad and add ideas and phrases that are not in the original."

"It's a matter of the period and the personality of the translator, whether he wishes to go back to the English of the time the work was written, or use modern English," says Peter Salm, who undertook his *Faust* translation in 1962 in part because he felt that many existing translations were outdated. "I was more intent on faithfulness and on a kind of modern or neutral English that was not specific to time." Yet when the publisher asked permission in 1985 to reprint *Faust*, Salm agreed only on condition he be allowed to revise it. "After 20 years, it was a different experience," he says.

Some translations, such as Pope's Homer, Robert Fitzgerald's Omar Khayyám, or even the King James Bible, have an artistic value that overcomes age and inaccuracy. Others degenerate quickly, transformed by time into something comic or just dull. "Somebody like Thomas Mann has aged very badly," says Hunt. "It's partly the fault of the translator; [H.T. Lowe-Porter] is just too Victorian. Mann was more ironic, and all the flowery phrases he used were meant ironically."

Over the years, literary criticism has offered many theories of translation. One school, exemplified by Vladimir Nabokov, calls for translations to be as literal as possible. But literalness may not be enough if the objective of translation is partly to make sense of an alien culture.

In the 1950s, P. K. Saha coined the term "transcreation" to describe the rebuilding of a work in a foreign language, including, if necessary, the creation of new words. Saha still feels that such a transformation is necessary for Western readers to appreciate writers like the Nobel Prize-winning Bengali poet, Rabindranath Tagore, whose works Saha has translated. The theory of transcreation, Saha says, "involves the question, What would the writer have done if he had written in the new language?"

Saha believes that Tagore's reputation in the West has been damaged by overliteral translation. But even transcreations alone are insufficient, he adds: "There is no such thing as an absolute translation. Anything that enhances it or enables readers, whoever they may be, to get as close as possible to the spirit of the original, I approve of that."

A translation, he says, "is like a math problem that you keep working on. It's an ongoing business. I like to quote Heraclitus, who said we never step into the same river twice. I replace 'river' with 'text.'"

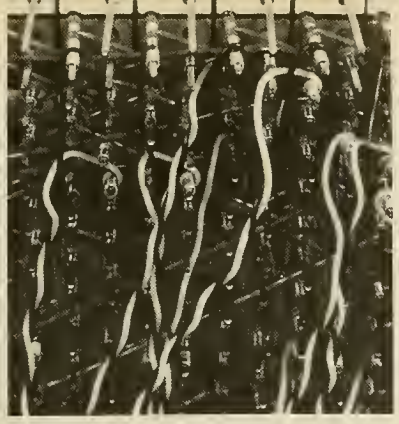
Julia Ridgely is assistant editor of the Alumni Magazine Consortium.

Achilles sing, O Goddess! Peleus' son;
His wrath pernicious, who ten thousand woes
Caused to Achaia's host, sent many a soul
Illustrious into Ades premature,
And Heroes gave (so stood the will of Jove)
To dogs and to all ravening fowls of prey . . .
William Cowper, 1791

Sing, Muse! Pelides' wrath, whence woes on woes
O'er the Achaeans' gather'd host arose,
Her chiefs' brave souls untimely hurl'd from day,
And left their limbs to dogs and birds a prey . . .
William Sotheby, 1834

Muse, of Pelidéan Achilles sing the resentment
Ruinous, who brought down many thousand griefs on Achaians,
And untimely banish'd many souls to the mansion of Hades
Of warriors puissant, them making a booty for hounds and
All manner of prey birds . . .
C. B. Cayley, 1877

The Wrath of Achilles is my theme, that fatal wrath which, in fulfillment of the will of Zeus, brought so much suffering and sent the gallant souls of many noblemen to Hades, leaving their bodies as carrion for the dogs and passing birds.
E.V. Rieu, © Penguin Books 1951



Bit by Byte by Brick by Wire: Putting It Together

WPI's unprecedented effort to computerize the campus

By Michael W. Dorsey

Photos by Michael Carroll

The year was 1959, just two years after the launches of the Soviet satellites Sputnik I and II. Since then, the Soviets had put a pair of monkeys in space and sent a rocket to the moon. A synthetic diamond was being created in South Africa, and the United States was about to launch the first nuclear-powered merchant ship.

That same year, a device the size of today's large copying machine was delivered to WPI's Stratton Hall. The machine, an IBM 610 Auto-Point Computer, had 80 storage registers, a console with a video display for entering instructions, and paper tape readers and punchers for input and output. It could multiply two 31-digit numbers in 3/4 of a second and print the result at 18 characters per second on an electric typewriter.

Compared with today's cybernetic powerhouses, the 610 was a mental midget. But it marked the beginning of the era of the digital computer at WPI, three decades that have taken the campus, and the world, through the wonders of high-speed data processing, timesharing, microprocessors, personal computers (PCs), supercomputers, and artificial intelligence (AI).

Today, WPI stands at the threshold of a new computer age. Already, the college is taking advantage of a host of new productivity-enhancing tools for financial record keeping, data base management, word processing, and communications.

And, in less than a year, an army of PCs, terminals, graphics work stations, minicomputers, and mainframes will be linked by a modern, high-speed campus data net-

David Cyganski '75, WPI's chief information officer, oversees all of the Institute's computer-related support services, from its mainframes to its 800 personal computers.

work. Then, in 1990, WPI's diverse computer and information science entities will be brought together in the new Fuller Laboratories.

"It's a great leap of faith," says President Jon C. Strauss. "We're making a major bet that technology can and should play a much larger role at WPI in the future than it does presently."

Strauss adds that as a technological university, WPI is "really in the information business, as both a developer and a disseminator of information. Therefore, we must make a major investment in technology now, even though we can't at this moment predict exactly where the progress will lie or how it will manifest itself. We must make a commitment to an approach and make it work."

That approach, quite simply, is to place as much of the power of modern computing at the fingertips of as many members of the WPI community—students, faculty members, and administrators—as possible, and to do so as soon as possible.

"The goal is to get our faculty and staff to use productivity tools where it makes the most sense," Strauss says. In order for faculty and students to make the best use of these tools, he adds, "we must make certain we provide computer resources to those people who need them, as well as appropriate training and support to help them use those resources effectively."

Toward these ends, WPI will spend nearly $14 million before the end of the decade in a major effort to computerize the campus, and has made enhancing the college's computer and information science facilities a major component in the current $52.5 million *Campaign for Excellence.*

"Computerizing the campus is not a new idea," says David Cyganski '75, associate professor of electrical engineering, who in 1987 became WPI's first chief information officer. Cyganski's responsibilities include overseeing all of WPI's computer-related support services, which range from servicing personal computers to running the college's large mainframes. "Computerization really began with the college's first computers," he says.

After the IBM 610 was retired in 1965, WPI acquired a newer, more powerful computer, the IBM 1620, which could be programmed in four computer languages and could accept instructions and data keyed onto punch cards.

"Through the late '60s we had that one computer," Cyganski says. "Only a few faculty members had the skills to use it. The Registrar's Office made the first administrative use of computers at WPI by electronically recording grades on the 1620."

Integrating the digital computer into the educational, research, and administrative life of the campus proceeded swiftly through the late 1960s. By the end of the decade, WPI had opened a new computing facility, the Worcester Area College Computation Center (WACCC), built in the basement of the Gordon Library with a $260,000 grant from the National Science Foundation.

WACCC's mainframe computers at one time provided data processing support to the WPI community and to as many as 50 colleges and institutions in the Northeast, though its work for other colleges is much reduced today.

Then, in the late 1970s, the personal computer appeared on the market, and the computer world, long dominated by powerful mainframe machines, underwent a revolution.

"Suddenly, we were in a very different computer environment," Cyganski says. "Now you could have your own computer on your desk. You could tailor it to do whatever you wanted it to do—solve specific engineering problems, for example—or remind you of appointments. And they were inexpensive enough that anyone who had a real use for a computer could afford one."

As PCs caught on, Cyganski says, WPI, like many other colleges of science and engineering, faced an important question: how best to introduce students to the power and utility of this essential technological tool. While some schools required students to purchase machines, WPI took a different approach.

The college decided to make many machines available for student use and to encourage faculty members to integrate the personal computer into course and project work, with the hope that, through frequent exposure, students would come to see the computer as an essential tool.

"Too often," he claims, "the computer can become a machine which students use by rote. We wanted them to learn that it is an effective and general tool. You don't just use it when a teacher hands you a disk with a program for a particular course. You turn to the computer whenever it is the effective way of working on a problem. We decided to create an environment that immerses students in computers—and hope they get awfully 'wet' while they are here."

To create that environment, WPI established the Office of Academic Computing (OAC) in 1983. The OAC, under the guidance of its first director,

Dean Owen W. Kennedy Jr. '45, and with a half million dollars in yearly support from WPI, began the process of acquiring AT&T personal computers, chosen, Cyganski says, because they provide the speed necessary for engineering and science applications.

The bulk of the PCs are distributed among several general access laboratories, where students can use them for class and project work. Other PCs are lent to faculty members for research and educational applications and to academic and administrative departments for a variety of office functions.

Today, nearly 800 AT&T PCs populate the offices and laboratories of WPI. Of these, more than 180 reside in open labs, where they are available to all undergraduates. More than half of the faculty have PCs on their desks and in their laboratories, and many have purchased them for their homes as well.

This strategy of making it easy for students, faculty, and staff members to find computers when they need them has worked well, Cyganski says. Students and faculty members here learned not only how to use computers, but why they are such valuable tools. And, members of the college's staff have discovered how the PC can enhance productivity.

The process has also been aided by a $1.2-million grant from the George I. Alden Trust, $1 million of which will go toward the construction of Fuller Labs and $200,000 of which has, over the last four years, helped faculty members use PCs to develop a host of innovative educational software.

"We grew the college into computing," Cyganski says, "at a reduced cost to WPI and its students, and with, I think, a higher level of utilization."

"We're trying to teach students how to think, not just how to program."

While getting PCs into the hands of those who need them has been a big job for the OAC, it would have been a futile effort without the support that the office also provides. A fully equipped maintenance shop, operated by David Veinotte, installs and services the hundreds of PCs owned by WPI.

The OAC also makes available a variety of copyright-free, public domain software and "shareware" packages, and provides training and assistance to anyone on campus who needs it. Donald Farley, supervisor of software operations, handles several emergencies and dozens of routine software-related queries from students, faculty, and staff members each day. He also tutors between 100 and 200 people each month in the OAC's computer classroom in Higgins Laboratories. Recently, the OAC began introducing software written by Cyganski and other on-campus programmers specifically for use by the WPI community. Two examples of this "WPIWare" will be distributed soon to all undergraduates. One package is a calculating program that can solve equations typed into it and the other translates numbers and equations into a variety of graphs.

"Our role," he says, "is to make sure that people don't just have the machine, but that they learn how to operate it and understand it."

So far, Cyganski says, the OAC has been successful at this job. Each year, more PCs find their way onto desktops, new student labs open to accommodate the growing need for computer time, and the burden on the center's training and repair staff grows.

While WPI's PC population continues to grow, Cyganski says he is more excited about another phenomenon, the growth of a middle ground between the college's PCs and its large, mainframe computers.

"Around campus, you will find groups of faculty members who need to have the capabilities and functionality of a mainframe computer, but without the additional hardware and staff required to operate a mainframe. The middle ground is populated by minicomputers, and we are seeing them used increasingly in research and education."

Along with minicomputers, Cyganski says, WPI is seeing the growth of interest in work stations—small, powerful computers that have the processing muscle needed to solve complex engineering and scientific problems and to make arcane concepts visible through high-resolution graphics.

Cyganski says he hopes to see the services provided by the OAC expand to cover these larger machines. Already, his operation is exporting technical services to support the Computer Science Department laboratories.

"I am excited at the prospect of this experiment," Cyganski says, "because it's the first time we will provide a service like this to a department, yet the department will remain autonomous in the application of the service. There was a day and age when, if something was being run by a computer center, you lost

James J. Jackson Jr. heads the Computer Services Center. Its three "big" machines maintain student records, run the college's accounting system, provide data processing, and store and process a wealth of other information.

Creating a "Time Machine" for the Scheduling Office

Kathy Frawley, associate registrar and scheduler, and Andrew P. Ferreira '87. His scheduling program, running on the PC in the foreground, made a big dent in the time needed to schedule WPI's undergraduates.

To many, the computer is something of a time machine. By automating labor-intensive, paper-and-pencil operations, it can reduce the time needed to do routine tasks, freeing up that time for more productive jobs.

Last spring, WPI's Scheduling Office was in desperate need of such a time machine. For years, Dean John van Alstyne had drawn up class schedules for each of WPI's 2,500 undergraduate students with nothing more than pencil, paper, and an uncommon knack for organization.

When he retired from his post as dean of academic advising last year, this mammoth task fell to Kathy P. Frawley, WPI's new associate registrar and scheduler.

"We started out, as Dean van Alstyne did, working strictly on paper," Frawley says. "We augmented this approach with a simple spreadsheet computer program. But, either way, it was very time consuming. The whole process took weeks."

Unknown to Frawley, a white knight was about to come to the rescue. Having noticed the effort Frawley was expending on scheduling, Andrew P. Ferreira '87 decided there had to be a better way.

Ferreira, a mathematics major who works part time in the Computer Service Center, went home to his terminal on a Friday evening and began writing a program in a symbolic computer language known as MACLISP.

"I came back on Monday with a program that would enable you to specify the courses a student wants to take and then let the computer construct every possible schedule that does not conflict," Ferreira says.

He notes that the program will construct as many as 500 possible schedules for each student, especially for students taking introductory courses, which often have many sections.

These schedules are winnowed as the computer works to make sure all sections of each course have about the same enrollment and attempts to schedule students for classes that meet at times that they prefer.

The result of Ferreira's effort was "phenomenal," Frawley says. "It took us a month working nonstop to get the scheduling done," she explains. "Andy's program takes about five hours to run. That leaves three weeks free to fine-tune the schedule."

So far, the program has been used twice to schedule the freshman class. Next fall, it will be used for the first time to schedule all WPI undergraduates. To this end, Ferreira says he is making some modifications, in particular enabling the program to give seniors first shot at courses in their majors.

Ferreira has also developed a program that manages the waiting lists during registration, and he will soon begin work on software that will help the scheduling office handle the task of assigning courses to classrooms.

He says creating these programs has been a satisfying experience, one that has also changed his career outlook.

"Before writing these programs," he says, "I was going to go right on to graduate school in mathematics and become a college professor. Now, I'm having second thoughts. I seem to fit in well with the people here. It will be a tough decision."

—MD

control. As computers and software become friendly, so must the provision of service. In fact, if there is a key word describing the whole new organization of computers at WPI, it is service."

"It's a great leap of faith. We're making a major bet that technology can and should play a much larger role at WPI in the future than it does at the present."

The first thing you notice when you enter the main hardware room of WPI's Computer Service Center (the successor to the WACCC) is the sound—a low, constant rumble of high technology in action. Everywhere, big disk drives spin, high-speed printers churn, and fans and air conditioners hum. This is the world of big computers, powerful, number-crunching mainframes that handle the "higher end" of the computer workload at WPI.

James J. Jackson Jr., the center's director, remembers walking through the doors of this room the day it opened in the fall of 1967. It was a smaller operation then. One mainframe computer handled the computing load for WPI and many other Worcester-area colleges.

Today, three big machines share this space. The veterans, a Digital Equipment Corporation DEC 20 and a Sperry Univac, have handled the college's academic and administrative jobs for more than a decade now. The newcomer is a DEC VAX 8700, one of the newest generation of general purpose computing machines.

The 8700 was purchased last year to handle the Institute's administrative computing duties, taking over this load from the aging Univac, Jackson says. But a new machine is only half of the story.

The VAX can operate several powerful new software packages that will replace software written by the programmers and analysts of the center over the past two decades.

"This is the first time we've written out a check to someone else for mainframe software," Jackson says. "All of our software for the last 20 years has been written in-house. I think that speaks well of the staff here."

Already operational are packages that handle WPI's accounting and personnel data bases and provide powerful word processing and other general office tools for the college community. This year, a new student record-keeping package and software that supports the management of the Alumni and University Relations Offices will be implemented.

"We've taken a major step forward with these systems," Jackson says. "We've spent a lot of money to outfit our administration with the state of the art. This should make WPI a more attractive place to work."

Much of the power of the new software lies in the flexibility with which users can add to and retrieve data stored in the computer, Jackson says. A so-called fourth generation language known as Oracle will enable users to ask for information with simple English commands, and get just what they need organized in exactly the manner they want, Jackson says—"and they'll be able to do so without any knowledge of computer programming."

For example, with the Student Information System running on the 8700, a faculty adviser will be able to access a student's record or look at how the course schedule is shaping up.

While users will find it easier to retrieve data, they will also take a more active role in entering that data into the computer, cutting the existing data entry load of the center, Jackson notes.

Computerization means different things to different people. To John Miller, vice president for physical plant, it means a busy construction program that began in the summer of 1987 and will continue through the fall of 1989.

"Last summer we installed about 1,000 linear feet of a bank of four-inch conduit through the heart of the campus," Miller says, "anywhere from eight to 16 parallel tubes." He says these tubes are allocated for either telecommunications or high-voltage power distribution for the new Fuller Laboratories and the planned renovations of Higgins Laboratories and Alden Memorial Hall (additional power is needed for a growing research program in Higgins and for the Humanities Department, which will move into Alden after the renovation). The conduit will also provide a physical path for future phone and data networks.

This new network of conduits, as well as an existing system of conduits and steam tunnels that runs along West Street and to many of the college's residence halls, will accommodate the lines for a digital telephone system and fiberoptic cables. Through these cables will whisk information at the dizzying pace of 10 million bits (about 850 double-spaced pages of typed information) per second.

The Ethernet computer network will be obtained from DEC and installed by Coghlin Electric Company of Worcester. The total cost of getting the network in place, Miller

Karen Lemone, acting department head, says Fuller Labs will allow the Computer Science Department to expand its teaching laboratories.

says, will be about $2.8 million.

To support the telephone system, the college will install a new digital phone switch in a new switch room to be constructed in the power house adjacent to the Washburn Shops. In consultation with Francis S. Harvey '37, president of Harvey and Tracy Associates, Inc., structural engineers, 1,000 square feet of new floor space will be provided above the existing switch gear room and will house the telephone switchboard and shops for technicians, in addition to the central switch itself.

"In the major academic buildings, we will be constructing satellite equipment rooms, or SERs," he says. "These will be small rooms containing the primary building electronics, telephone, and data cable terminations—even video cable terminations. They'll be the primary electronic distribution points for the buildings."

From the SERs will run a backbone of coaxial cable and telephone wire that will terminate at desk and workplace locations throughout the college's academic and administrative buildings—more than 900 in all. At these locations will appear new faceplates with connections for high-speed data communications, computer terminals, and telephone equipment.

"With the new network, we'll see a fundamental change in the way business gets done on this campus," says David Cyganski. "The most immediate boon will be in the area of casual communications. We've always had electronic mail on our mainframe computers, but that was available only to those who had terminals. I think we will see a real blossoming of electronic mail. And I expect that not turning on your PC in the morning to get your mail will become as unacceptable as ignoring your mailbox."

The network will also accomplish the most fundamental goal of the computerization of the WPI campus, he says: linking its diverse collection of computing machines into a single entity.

"We're seeing the creation of a pyramid of computers, each level of the pyramid having its own purpose. Half the trick is finding the level that's most appropriate for getting your problem solved efficiently. The 'elevator' between the levels will be the network. The network will allow anyone to tie his or her computer to virtually any other computer on campus."

And, with software donated to WPI by Ronald Howard '77, president of Datability Software Systems, users will have what is known as trans-

Lights, Cameras, Education!

Just as computer technology has undergone profound changes over the last few decades, so has the technology of education.

Audiovisual aids for education once consisted mainly of filmstrips and 16mm films. Today, computer-aided learning, videotapes, projection television, and interactive videodisk programs are all finding their way into classrooms and teaching laboratories.

Helping provide faculty members at WPI with the resources they need to create and use modern instructional aids has, for two decades, been the province of the Instructional Media Center (IMC).

The IMC was the brainchild of Kenneth E. Scott '48, professor of mechanical engineering and director of instructional television. Scott began by making videotapes for his own courses in the late 1960s and later offered this service to other faculty members.

In time, his operation found a home in the basement of Higgins Labs, one that has grown from a single room to a suite of offices, video production facilities, a television classroom, and a variety of modern graphic arts equipment.

When the Fuller Laboratories building is completed in 1990, the IMC will have a permanent home there, along with the Computer Science Department, the Computer Service Center, the Office of Academic Computing, and a 400-seat auditorium with modern AV facilities, which the IMC will manage.

In its new home, the IMC will continue to perform its many services for the WPI community, including the production of slides and overhead transparencies, many made with a new computer graphics system, and operating a campus-wide closed-circuit television system, which includes a community bulletin board.

The bulletin board, which began about ten years ago as three-by-five cards revolving on a motorized wheel before a black-and-white TV camera, is now run by a computerized, high-resolution character generator. It is the most visible element of the IMC's video services, which include the creation of educational videotapes used by faculty members to augment their courses.

With the implementation of the WPI Plan in the early 1970s, Scott's video production service was in great demand. In time, a library of nearly 2,000 tapes was accumulated, and Scott's staff created an AV room in Gordon Library where students could view them.

While interest in making educational videos has waned, the computerization of the campus may spur the production of new tapes, since video is an excellent medium for instruction in computers and computer software, according to Douglas G. Thompson '78, IMC engineer and supervisor and the center's key video producer.

"If there is one thing that I wish I could do, it is to get faculty members to come in and make more tapes," says Thompson. "Our tape library is rapidly dwindling."

Currently, the IMC distributes videotapes for use in various off-campus educational programs, but it may eventually expand into new areas. "In the future, I wouldn't be surprised if this were done by satellite," Scott says.

With the installation of the new computer data network, the IMC may well give up one of its long-standing jobs: the VTN, or virtual terminal network, the campus' first data network, which it installed more than a decade ago and has maintained ever since.

Scott and his crew ran the wires for the network, which connects 400 terminals and 60 fire and security alarms around campus, for just $18,000.

"When you compare it with the cost of the new network," Scott says, "that was a real bargain."

—MD

Douglas G. Thompson '78, instructional media center supervisor, mans the controls while Kenneth E. Scott '48, director of instructional television, works on-camera to tape a lecture.

parent connectivity. Essentially, Cyganski says, this means that you may use your PC to talk to a mainframe, but it will appear that the mainframe is really an extension of the machine on your desk.

The combination of transparent connectivity and high-speed communication, Cyganski notes, will make it easy to collaborate with other computer users on projects, to send and receive large amounts of data, to create documents at one location and print them at a remote location, and to talk to users all over campus and, through links to national and international computer networks, to users all over the world.

"We decided to create an environment that immerses students in computers—and hope they get awfully 'wet' while they are here."

Today, it consists only of floor plans and architect's drawings. But soon, ground will be broken for Fuller Laboratories, WPI's new Information Sciences Building. Information is the key word in that title, Cyganski notes.

"We have recognized that computer science—computers themselves, computer application services, and communications, of both the computer data sort and the video and audio sort—are all part of information science. It is becoming one very interactive group of activities. That building really stands as a symbol of the interrelated quality of all those activities."

Ground will be broken in late spring for Fuller, the most ambitious phase of the physical component of WPI's computerization. With 60,000 square feet of floor space distributed among three floors and two basements, Fuller will house the Computer Science Department, the Computer Service Center, the Office of Academic Computing, the Instructional Media Center, a 400-seat auditorium, and the hub of the new computer network.

The largest tenant will be the Computer Science Department and its 12 faculty members, 171 undergraduates, 46 graduate students, and four staff members. The department now has offices and labs in both Atwater Kent Laboratories, which it shares with the Electrical Engineering Department, and Washburn Shops.

By consolidating its operations under one roof, the department, one of the first in the nation to receive accreditation, hopes to be able to achieve two of its main goals: to expand a curriculum based largely on laboratory work, and to create modern laboratories dedicated to computer science research, according to Karen Lemone, acting department head.

"A few years ago, we switched to teaching our courses in a lab environment," Lemone says. "Rather than using the campus' main academic computer—the DEC 20—for all of our courses, we obtained special equipment from Digital Equipment Corporation to start VAX Labs, which we use for our introductory assembly language sequence and several other courses."

For the students, she says, the VAX Labs create environments where everyone in the room is working on common problems: "There is a lot of cooperation and reinforcement among the students. This is an effective way to learn computer science, and we hope to expand on this method with more labs in the new building.

"We have designed our space in Fuller Labs completely from the lab point of view," Lemone says. "But we've made an improvement in our current situation by having dedicated labs both for education and research. We have a strong artificial intelligence research group here, and we're especially looking forward to having labs and equipment dedicated to their research."

The new equipment and space the department will acquire with the completion of Fuller Labs will make the job of teaching and research in computer science a bit easier. But it will not solve a major problem the department, and all users of computers at WPI face: the rapid changes taking place in computer technology.

"You have to face the fact that every few years you have to upgrade computers in the same way you have to upgrade any other technology," Lemone says. "That's something we have to work into our plans. But more important, our curriculum must be constantly changing because we want everything we teach to be state of the art."

As technology moves on, Lemone says, the department must maintain a balance between the fundamentals of computer science, including

languages and language processing, and the constantly changing "hot topics," which now include robotics, artificial intelligence, and computer-integrated manufacturing.

For example, the department has introduced a networks course at the undergraduate level for next year. This is a course previously taught only at the graduate level. "And, we will soon offer a brand new introductory course that uses a much more advanced approach to computer science," she adds, "with less of an emphasis on programming and more of an emphasis on concepts. After all, we're trying to teach students how to think here, not just how to program.

The smallest tenant in Fuller will be the Instructional Media Center (IMC), which, under the direction of Kenneth E. Scott '48, provides a variety of audiovisual and graphic arts services to the campus. Both Cyganski and Jon Strauss say they hope that having the college's computer resources and the IMC in one building will spur the combination of computers and video technology for the support of the Institute.

"The time between when something is relevant and when it has absolutely nothing to do with the real world is down to about six years."

"With luck," Strauss says, "proximity will promote serendipity, and we'll take a leading position in the use of new technologies in instruction."

David Cyganski points out a pie chart in a recent issue of the magazine *IEEE Spectrum*. The chart, he says, indicates that software and software-related items currently account for about 5 percent of the gross national product. That figure concerns Cyganski. "To me, that says something about the changing role of computers in our society," he says. "They are becoming an essential component of business and of many other facets of modern life. For WPI, this means that, in addition to all the other fundamentals we must teach students, we must add a new fundamental—that of the computer.

"Ultimately, for our survival, let alone to accomplish our educational mission, we have to prepare our students for what they will find in industry and at other institutions. Industry will adopt new technologies because of the efficiencies they make possible. We would be remiss if we did not create the same environment here that students will be working in when they graduate."

But, that task becomes more difficult with each passing year. Technological development accelerates in an exponential fashion, Cyganski says, and the farther along society moves on the technology curve, the faster technology changes.

"It wasn't so hard to catch up when we were farther back on the curve," he says. "The Washburn Shops could have been 15 years behind and students would hardly have noticed. Now, the time between when something is relevant and when it has absolutely nothing to do with the real world is down to about six years, and the leeway is growing shorter and shorter."

That shrinking window of relevance makes the steps the college is taking now toward computerization all the more important, Cyganski adds: "Think of this—the 8080 semiconductor chip, on which the first PCs were based, was introduced 12 years ago. Today the personal computer is one of the most important cogs in the wheels of American industry. Now, we're even farther up the technology curve."

Computerizing the Classroom with the Alden Trust

"We are witnessing a major change in the evolution of the activities of man," wrote Edmund T. Cranch, WPI's 12th president, in a 1984 request to the George I. Alden Trust for funds to enhance the Institute's computing facilities and capabilities.

In answer, the Alden Trust granted WPI $1.2 million, of which $1 million will help build Fuller Laboratories. The rest was reserved to help the faculty incorporate the computer into the curriculum.

Most of the money has been used by faculty members to develop computer applications for courses in subjects ranging from communications engineering and differential equations to American urban history and financial management.

So far, these applications have been used successfully in more than 20 courses. With these programs, undergraduates are performing laboratory experiments in chemistry and electrical engineering, among other subjects; tackling exercises in physics, statistics, and economics; and receiving computer-aided instruction in such fields as electrical communications and linear algebra.

Some who received Alden grants developed "computerized homework" for students to take back to their own computers or to the many machines in open-access laboratories around campus. For example, James Demetry '58, professor of electrical engineering, devised software that enables students to learn the basics of electrical controls through solving individualized problems.

Many of the faculty who took the time to write their own programs also evaluated "off-the-shelf" software developed for their subject areas, but discovered that these generic packages rarely offered them the flexibility necessary to tailor the software to their own teaching approach.

And, while these faculty members report that students do not always enjoy the computer-based exercises as much as more conventional approaches to teaching, they learn computer-taught concepts better and faster.

While it is difficult to measure the benefits students and faculty have gained and will continue to gain from this "computerization of the classroom," the generosity of the Alden Trust is already producing some tangible rewards. For example, in 1986 four of the papers published in the *Annual Conference Proceedings of the American Society of Engineering Education* were reports on courseware developed by WPI faculty members. All the programs were developed with Alden grants.

—MD

Two decades
after its founding,
the Worcester Consortium for Higher Education
continues to bear
the stamp of
Harry P. Storke, WPI's 10th president,
whose vision helped to build
this 24-member alliance.

Making Company, Making Tracks

By Jerome A. Parchois

Quietly, with perhaps only a discreet round of handshakes and collegial reminiscences among a concerned few, the Worcester Consortium for Higher Education marks its 20th anniversary this year. While the celebrating may be low-key, the partnership of 10 area colleges and 14 associated cultural institutions has plenty to feel good about. Although the consortium was incorporated in 1969, its work actually began a year earlier with the inauguration of cross-registration, making it among the oldest of the nation's 100 or so similar associations. Creation of the alliance helped put an urgently needed collegiate face on an old mill town not recognized then as a center of higher learning.

The group is now active in close to 20 different areas of cooperation, ranging from joint purchasing and interlibrary book lending to its gerontology studies and off-campus internship programs. The consortium also extends its concerns statewide through the sponsorship of six Educational Opportunity Centers, which each year provide educational counseling and scholarship information to more than 6,000 people.

Launched on a shoestring budget and with a part-time staff of two, the consortium operates today on an almost million-dollar budget administered by a staff of 32. Its programs are run for the benefit of Worcester's 31,000 students. And as an industry, the consortium schools generated an economic impact on the Worcester area surpassing the $1-billion mark for the first time in 1986.

The consortium's executive director, John W. Ryan, emphasizes that one of the keys to the organization's effectiveness is the tight geographic base that Worcester provides. All member schools are no more than 20 minutes apart, and several are connected by the consortium's own shuttle vans, operated by stu-

What makes the consortium unique is that "each school has its own focus. Collectively, they don't attract students from the same pool," says John W. Ryan, executive director. The Worcester Consortium for Higher Education is one of the nation's oldest intercollege collaboratives.

Michael Carroll

dents who, from the consortium's beginning, have been members of the WPI chapter of Lambda Chi Alpha fraternity.

"One of the things that makes the consortium unique," Ryan says, "is that each school has its own focus. Collectively, they don't attract students from the same pool. In that way, there's little competition." On the other hand, this diversity at times made getting the consortium off the ground a difficult task, one that required the good will and cooperation of many people.

Barbara Guthrie, a long-time administrative assistant at the consortium, notes that "turf issues continue to surface. And concerns over quality of member institutions tended to hinder cooperation in the early days."

"Nothing ever seemed to fall nicely into place," recalls Lawrence E. Fox, who preceded Ryan and was the consortium's executive director for 11 years. "It was all hard work."

In many ways, the spiritual founder of the consortium was WPI's 10th president, the late Harry P. Storke. He was a West Point graduate who achieved the rank of lieutenant general before retiring from the Army. A skilled field commander and former chief of information for the Army, he was an energetic organizer naturally inclined to making the most of the resources at hand. During Storke's seven-year tenure at WPI, he oversaw a major expansion of the campus, including the completion of Daniels Hall and the construction of Goddard Hall, George C. Gordon Library, Harrington Auditorium, and Stoddard Residence Center. In the same period, enrollment doubled, the college began admitting women, and a faculty committee was appointed to begin work on what became the WPI Plan.

When he arrived at WPI in 1962, Storke was struck by the number and diversity of educational institutions in Worcester, a situation he later said "contained the seeds of an education center which could be a model for progress throughout our country."

"The consortium began almost by accident," recalls Roger N. Perry Jr. '45,

director of campaign communications at WPI, who was then in charge of public relations at the school.

The project that was closest to Storke's heart, and the one where he saw the greatest potential economies of scale and promise for the future, was the creation of a great computer center to meet the increasing needs of Worcester's schools, industries, hospitals, and professional groups.

Perry recalls that Storke intended to propose his plan in a speech at the Worcester Area Chamber of Commerce "Salute to Education" dinner gathering in November 1965. But Perry suggested to Storke that the president offer the idea of a Worcester-area college computer center in a more comprehensive context. "I said, 'Why don't you consider listing several things that you'd like to see accomplished, and then if the [computer center] idea falls flat, at least you haven't lost everything,'" Perry recalls. "He said, 'I don't care. Put down whatever you want.' I said, 'How about a nice ten-point program?' He said, 'Go ahead.' The computer proposal, of course, was right in the middle of it."

Storke's address, entitled "Worcester—All-American Education Center," included proposals for encouraging faculty exchange, eliminating costly duplicate facilities, expanding undergraduate evening courses, and promoting joint public relations. (He noted, with foresight, that "our Worcester image needs reglamourizing.")

Acknowledging that others had already glimpsed the possible advantages of increased cooperation between institutions, Storke characteristically came right to the point: "What I will emphasize tonight is that it is time for us to *do something*."

Storke's vision of a microchip-based cooperative was never actually realized on the scale he had envisioned, although a more modest, WPI-centered computer operation known as the Worcester Area College Computation Center (WACCC) was subsequently established.

The late Harry P. Storke, WPI's 10th president, was, in many ways, the consortium's founder. A natural organizer, he was struck by the potential for creating a great education center in Worcester. It was his speech to the city's Chamber of Commerce in 1965 that set planning for the consortium in motion.

According to the Rev. Georges Bissonnette, Storke's primary aims were to eliminate duplication of effort—and expenditures—and capitalize on each school's special strengths. Storke and Bissonnette, who is vice chancellor for community affairs and former president of consortium member Assumption College, go back a long way together—some 20 years, to the War College in Carlyle Barracks, Penn., where the two had taught. Storke began working behind the scenes, Bissonnette says, lobbying fellow college presidents and other interested educators.

The art of convincing others, though, was not a prominent element of Storke's managerial repertoire, Bissonnette recalls. "When you've been a general as long as he had, you can loose the ability to persuade people. You pull rank on them. But although he was much too smart to think he could pull rank on civilians, he could never shake off the idea that the appeal of an idea should be as clear to everybody else as it was to him.

"The consortium began almost by accident," recalls Roger N. Perry Jr. '45, director of campaign communications at WPI. Knowing that President Storke wanted to establish a major computer center for Worcester's colleges, Perry convinced him to propose the plan as part of a 10-point program. In it were the seeds of the consortium.

Michael Carroll

Therefore, I became his salesman."

Cooperation among Worcester's colleges had already received the enthusiastic support of Clark University's president Howard Jefferson. In fact, a degree of cooperation had been achieved between Clark and WPI through limited cross-registration and a co-administered biomedical engineering course.

What was needed most, Storke said, was wide-scale provision of technical services. But reaching that goal would require the formation of a group that could generate the financial resources necessary to purchase advanced computer and support facilities.

A forerunner of the consortium—a forum of local college presidents called the Committee of Seven—had been formed in 1967 to explore areas of mutual interest. "We had God knows how many lunches and dinners and breakfasts with the college presidents," says Bissonnette. "But as time went along, they started coming in and making suggestions, and that's when we knew they were on board."

That in turn led to a formalization of long-standing contacts which had also been growing among purchasing officers, librarians, and faculty members at the various schools. The consortium was clearly an idea waiting to happen.

The turbulence and uncertainties of the late 1960s also encouraged the various college administrations to cooperate more closely. The rapid social and technological advances of the time and the sudden availability of large amounts of federal funds seemed to point to the need for a more collective approach. But, Perry recalls, the consortium's proud, new three-arrow emblem seemed to symbolize contradiction. "We finally decided that it meant students, faculty, and administration—each going his or her own way," he says with a laugh.

Shortly before his retirement in 1969, Harry Storke, the inveterate organizer, went on to found and become the first vice president of the Association of Independent Colleges and Universities in Massachusetts (AICUM).

The consortium's charter offering, cross-registration, has declined in popularity since its inception, down from

about 1,000 annually 10 years ago to 900 today. The reason, according to John van Alstyne, lies largely in the differing academic calendars of the member institutions. A professor of mathematics at WPI, van Alstyne was deeply involved with the consortium for 15 years in his post as dean of academic advising at the Institute.

"The colleges have basically been unable to find compatible schedules," he says. "It's been disappointing in that respect because a lot of potential has never materialized."

Ryan notes that the fact that only five of the city's colleges—WPI, Clark University, Holy Cross, Assumption, and the University of Massachusetts Medical Center—are linked by the shuttle service also diminishes the impact of the program. Another factor, van Alstyne suggests, may be a diminished interest in foreign languages, which since the early 1970s has accounted for the single biggest segment of cross-registration. Still, van Alstyne adds, "cross-registration has been a success when it has enabled students who were unsure of their major field of study to try something in a totally different area."

Timothy A. Blake, a junior at WPI who is majoring in mechanical engineering, has already taken two French courses at Assumption and another at Holy Cross. "I definitely benefited from it," he says, "but I think the program could use some improvements. Better coordination of semester breaks would cut down on interference with cross-registration."

Another WPI student, Maria M. Mathieson '90, says that after taking a 14-week Russian course at Clark, she discovered that she only received the credit equivalent of one seven-week course at WPI. "Something needs to be worked out with that," she says.

But for those pursuing interdisciplinary degrees, the variety and flexibility offered by the consortium's vast collective curriculum is an important asset. Says Jonathan A. Malin, a WPI computer science graduate student interested in neural networks, a subject involving elements of mathematics, biology, and psychology, "Cross-registration creates in the consortium schools what amounts to a super-university in Worcester."

And cross-registration can have more personal benefits, as Gary Strum, a senior majoring in psychology at Clark University, discovered. Strum enrolled in a course in artificial intelligence at WPI, he said, "less for the content than for the chance to learn more about students at other schools. It was very valuable."

Strum says students at Worcester's colleges often have stereotypes about students at the other area colleges, misconceptions that can be quickly overcome by taking advantage of cross-registration. "You find out that people are people everywhere," he says.

From a financial standpoint, the consortium's major program is in the realm of joint purchasing of commodities necessary for the everyday operation of member institutions: office supplies and furniture, paper towels and toilet tissue, polyurethane bags, paint and painting supplies, chemicals, landscape materials, light bulbs, and, most importantly, close to four million gallons of fuel oil a year.

The Joint Purchasing Committee is exploring new areas in which they might save money, such as a collective trash dump fee and travel services. Still, there are limits to what it can accomplish because of purchasing arrangements the colleges have with other associations, like the Massachusetts Higher Education Consortium. Nevertheless, Ryan estimates the total savings at over $1 million annually.

Not least of the benefits, reports Clark University business manager Jack L. Foley, is the exchange of information with other business managers. "The dollars saved are great—and they're tangible," he says, "but I've also learned a lot from working with my colleagues in the consortium."

In addition to cross-registration and joint purchasing, the consortium offers services such as shuttle transportation for all consortium students. The shuttle service employs 25 drivers and two managers to provide about 60,000 student trips a year among member institutions. In fact, the shuttle's printed timetable is so extensive that it looks more like a long-distance bus schedule than an intracity van schedule.

"Cross-registration creates in the consortium schools what amounts to a super-university in Worcester."

In other vital areas, the consortium's interlibrary loan program helps avoid redundant acquisitions and provides access to three million books, periodicals, tapes, and other resource materials currently held in consortium member libraries. About 25,000 books are involved in interlibrary exchanges each year, or 1.4 books per consortium student.

The Health Studies Option and its more specialized offshoot, the Gerontology Studies Program, take advantage of consortium resources in health care services and administration, including those at the UMass Medical Center. The Health Studies Option, which enrolled about 800 students last year, and the Gerontology Studies Program, which attracted 100 students and leads to a certificate, provide opportunities for internships and research in laboratory settings. "No institution on its own could afford to have a program like this," notes Ryan.

The Consortium Tuition Waiver Pro-

The Rev. Georges Bissonnette, vice chancellor for community affairs and former president of Assumption College, worked with President Storke behind the scenes to convince the presidents of Worcester's colleges of the consortium's benefits.

gram, under which 250 Worcester public school teachers have taken enrichment courses since 1984, reflects the consortium's close relationship with the city's school system. Up to 100 students are provided with tuition annually.

The New Technologies Safety and Health Institute, established jointly in 1986 by Clark University, the UMass Medical School, and WPI as a consortium program, is involved in the risk assessment and control of occupational and environmental hazards. The institute, which is intended to serve as a national clearing house for all such information, sponsors an annual conference.

In February 1988, the consortium is planning a job fair at Assumption College aimed at showing more graduates from member institutions the professional, cultural, and social advantages of remaining in Central Massachusetts following graduation. Fifty companies have agreed to participate. "There are a growing number of careers in the Worcester area, particularly in the service sector, and we'd like to give our students first crack at them," says Ryan.

Another program currently on the drawing board will assist about a dozen disadvantaged young people a year—monitoring their progress through high school and providing them tutors, counseling, and other assistance. If these students complete the program, Ryan says, every effort will be made to have them admitted to the colleges of their choice. And if that school is a member of the consortium, the students will attend free of charge.

Prospects for other ventures are somewhat uncertain, Ryan allows, because, while it continues to provide a useful framework for new activities, "the consortium has reached a mature stage in its development, in which we are essentially refining our existing commitments."

Other factors also influence the consortium's future. On one hand, the member institutions themselves still have their own priorities and programs that they feel they can best undertake. On the other hand, the colleges' participation in other, larger groups like AICUM and the Massachusetts Higher Education Consortium to some degree preclude expansion of the consortium's role.

Looking back, though, no one can deny that much has been accomplished since Harry Storke first came to town.

Jerry Parchois is a free-lance writer based in Worcester.

MEMORY BANK

Winthrop Brown '14: A Wonderful Life

By Roger N. Perry Jr. '45

At 96, Winthrop B. Brown's zest for life is as strong as ever. He returned last year from his third vacation in Yugoslavia, and an article of his recently appeared in a national publication of the Presbyterian Church. Brown's only concession to his age is his reluctant use of a cane.

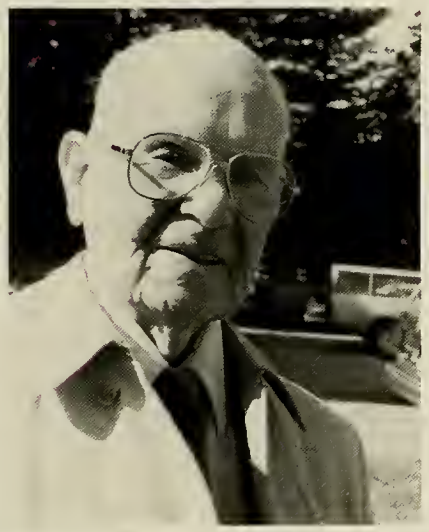
Nearly 75 years ago, Brown left WPI with a degree in chemistry, fully expecting to pursue a career in that field. In the ensuing years, though, Brown's life and work have taken him beyond the chemistry lab and into fields as different as investment banking and corporate law.

On a recent visit to WPI, he recounted his varied career with the ease of an accomplished storyteller. He began as a chemist in the coal fields near Pittsburgh, where he developed an ash fusion test that became a new industry standard. With $35, he designed and built an optical pyrometer that did the job of a $1,200 furnace. He says he left the coal company after several years when an expected raise was half what he'd anticipated.

"That was the end of chemistry for me," he says. "I had a growing family then, and I decided to go into sales. A friend suggested investment banking. That's where the money was then. I didn't know anything about that, but I figured I could learn."

And learn he did. He became a Pittsburgh representative of Dillon, Reed in New York, where he remained until the Crash of '29. Then he helped manage a small oil company until, "squeezed out by the big companies," it filed for bankruptcy.

"In the '30s, one of the big banks in Pittsburgh approached us about marketing a large block of Pittsburgh Steel



Winthrop Brown, shown here on a recent visit to Goddard Hall, began his career in the coal industry with $35 and a new invention.

Foundry stock, which we did. As a result, my partner became a member of the board. At that time, we were one of the three companies in the country that could make really large steel castings. During World War II, we made all the anchors for battleships. Every anchor had to be X-rayed for flaws and we had what was then the largest X-ray machine in the country."

After his longtime partner became president of the firm and he became corporate secretary, Brown decided to leave business behind for corporate law. Although he wasn't a lawyer, he used his background in banking and business to advantage, working with the Pittsburgh law firm of Reed, Smith, Shaw and McLay: "That was a very rewarding way to finish my working career."

In retirement, Brown moved to Pompano, Fla. Active in their church throughout their lives, he and his wife became involved in the large Presbyterian church there. The Browns traveled a quarter of a million miles through the U.S. and Mexico by trailer and motor home.

Brown's wife died five years ago. He continues to live in St. Andrew's Estates, a retirement home "which has everything you need to be comfortable."

If there is one memory of which he is most proud, it would be a time in the early 1920s when he was living in Irwin, Penn., a small town 21 miles east of Pittsburgh.

"It had been run by the same group of old boys for many years, and they were only interested in keeping taxes down. Several of us younger folks got together and decided we'd run for every town office in the next election and turn things around. We got every one of our group elected. I got the school board."

Brown inspected the grammar school and was appalled by its physical condition. The town hired an architect and renovated the building to make it safe, sanitary, and more attractive. "We held an open house and there were cheers from everybody," Brown said.

Similar attention was devoted to the academic program, with the result that "Irwin ended up with some of the finest schools in the country. And nobody complained about paying a little more taxes at the time," notes Brown.

Winthrop Brown was raised in Maine and graduated from Portland High School. He wanted to go to Bowdoin, but his parents suggested WPI.

"When John Boynton proposed building this school, he said he wanted it to prepare people to run the factories of the future," Brown notes. "As I look back, Worcester Tech did a pretty good job of doing that for me, and I'm grateful."

Roger Perry is director of campaign communications at WPI.

FINAL WORD

Back in the U.S.S.R.: WPI's Patrick Dunn Visits Worcester's Sister City

By Amy Zuckerman Overvold

The students in the robotics laboratory huddle over their instruments, working intently on ways to implement control systems in a canning operation.

In another lab, a plant science major studies biological controls for insect pests.

These scenes might be familiar to anyone at WPI, but the setting would not, for the school described here is the Leningrad Agricultural Institute in Pushkin, a Soviet city 10 miles from Leningrad.

Pushkin recently became Worcester's "sister city" in the Soviet Union. Last fall, Patrick P. Dunn, associate professor of history at WPI, visited Pushkin as part of a small Worcester delegation that included Mayor Timothy J. Cooney Jr.

Dunn's research interests include Russian and Soviet history. He said the official reason for the visit—set up under the auspices of Sister Cities International—was to begin a formal exchange between the two cities.

"The only thing we were promised," Dunn says, "was that Worcester area citizens going to Leningrad will be welcomed by the people of Pushkin. From that understanding will hopefully evolve peace [between the U.S. and Soviet Union]."

But as Dunn toured local institutions or attended events, including the Leningrad Circus, a very private purpose for his trip emerged. He became determined to find some link between his work at WPI and educational and cultural life in Pushkin.

The most obvious connection was the Agricultural Institute. With its 10,000 students pursuing degrees in fields like mechanical engineering, biotechnology, and robotics, the Pushkin Institute is similar in many ways to WPI.

During the three hours he spent at the school, he found much to commend and a number of things to question. In fact, Dunn says the school appeared to be a microcosm of Soviet culture, a society with many strengths and weaknesses.

For example, though students have some choice as to where they will get their higher education, Dunn says that most agree to attend the school to which the state assigns them, since this guarantees them a free education. By accepting this choice, students are also assigned their first jobs after graduation, which allows the government to place professionals based on need, not economics.

"The only thing we were promised was that Worcester area citizens will be welcomed by the people of Pushkin."

Taking the financial concerns out of education has its advantages, Dunn says. The Soviet students he met seemed surprisingly free of career and job concerns. "They concentrate on their studies," he says. "It would be wonderful if in the U.S. students could have economic pressures lifted."

This freedom from financial worries was balanced, however, by the loss of other freedoms, Dunn notes. Nowhere was this more obvious than in the narrow intellectual horizons of the Soviet students. Although extremely competent and more aware of world events than most U.S. students, to Dunn they seemed intellectually limited by the government's interpretation of information and the limited amount of facts it disseminates.

"The first thing you notice in the U.S.S.R. is the lack of information. There's one newspaper, no news magazines, and no TV news analysis," he explains. "It's not so much telling people what to believe as the lack of information."

In other ways, though, Dunn found the Soviet Union a far more liberal place than when he last visited 14 years ago. For example, the Soviet people no longer seem to be suffering from an inferiority complex.

"They feel equal," Dunn says. "They don't have to prove anything. This means they can be more open about their failings, but also more independent of the U.S. I don't think they will make compromises to get along."

These changes seem to be, at least in part, the result of *glasnost*, the Gorbachev government's attempt to liberalize the Soviet Union, Dunn says. As a good indicator of this new policy, Dunn points to his guide, who was openly critical of the quality of Soviet goods. Such criticism would have been impossible in 1973, he says.

Dunn was also surprised at the prevalence of rock music. "It's everywhere," he claims. "The state is harnessing rock concerts—the rebelliousness of youth—to make changes in the system."

Since his return from Russia, Dunn has been working hard to encourage WPI students to visit the Soviet Union with him this spring as part of a student exchange.

While in Pushkin, Dunn found a student leader at the Agricultural Institute who will meet visiting WPI students and give them a tour of the campus. And, he notes, the fact that a third of the Russian students speak English will largely remove the language barrier that could stand in the way of such an exchange.

Though Dunn has no illusions that these sorts of exchanges will resolve the differences between the U.S. and the Soviet Union, he says they do "enable Americans to see Soviet life and culture on a less superficial basis."

Opposite: Patrick Dunn, associate professor of history, with some mementos of his most recent trip to the Soviet Union.

Michael Carroll

EXCELLENCE IS...

Dr. Alexander E. Emanuel

The George I. Alden Professor of Electrical Engineering

When all is said and done, it is the faculty that determines the stature and vitality of an educational institution. And for every professor, a distinguished chair represents the pinnacle of excellence in teaching and scholarship.

Alex Emanuel, current holder of the Alden Chair, is the only WPI professor to receive the Trustees' Award for *both* teaching and creative scholarship. An expert in electric power systems science, he values particularly his time spent nurturing young minds.

"Growing the seed takes time," he says, "but seeing the plant bear fruit is so satisfying. And helping students learn how to ask the right questions can be as vital to their futures as finding answers."

At the same time, Emanuel says, "There's a detective in me that wants to unveil the secrets of nature." His research enjoys extensive sponsorship in the power engineering community. Right now, for example, his detective work includes learning about the "pollution" effects induced by harmonics and other phenomena generated by power systems.

WPI enjoys the benefits of a few distinguished chairs—Alden, Fletcher, Fuller, Merriam, Stoddard. Collectively, their incumbents represent the Institute's highest level of scholarly achievement. Yet the college needs more such scholars. In at least a dozen subjects, a distinguished faculty appointment would materially enhance the stature of WPI.

Providing the means to endow faculty chairs like that held by Alex Emanuel gets to the heart of the academic enterprise. Your commitment to this venture can ensure for tomorrow's scholars and students the academic excellence that is so much a part of WPI's heritage.

Support the Campaign for Excellence.

Biotechnology in Worcester ◆ A Medical Revolution

WPI Journal

ORCESTER POLYTECHNIC INSTITUTE SPRING 1988

Spring arrives in the gardens of Higgins House. Photo by Michael Carroll. Black-and-white, 8-by-10-inch prints of this photo are available; send $10 to WPI Journal, 100 Institute Road, Worcester, MA 01609.

WPI JOURNAL

VOLUME XCI NO.4
SPRING 1988

CONTENTS

6 **The Making of a Medical Revolution** *Michael V. Shanley and Paul Susca*
Five alumni who changed the face of medicine.

12 **Biotechnology Meets the Perpetual Motion Engine** *Michael V. Shanley*
Worcester's Biotechnology Research Park takes flight.

I **Lessons from Not Long Ago** *Julia Ridgely*
Sorting out the recent past for curious students.

VIII **Home Sleek Home** *Mary Ruth Yoe*
Do the gadgets that crowd our counters and closets really save time?

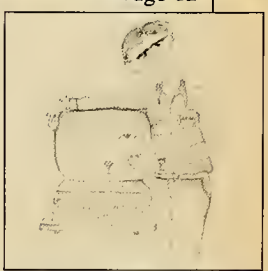
XII **Zoos, Tunes and Gweeps** *Elise Hancock*
A crash course in campus "slanguage."

33 **74 to 1** *Evelyn Herwitz*
WPI's first women undergraduates paved the way for those who followed.

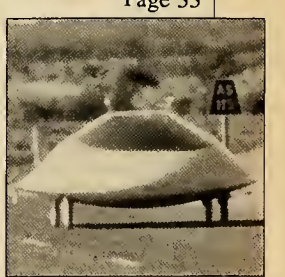
39 **A Personal Adventure** *Edward N. Clarke*
Across Australia with the World Solar Challenge.

Page 6

Page 12


Page XII

Page 33


Page 39

DEPARTMENTS

2 **Advance Word:** New science, new industry. *Michael W. Dorsey*

3 **Input:** Thoughts on modern medicine. *Thomas A. Shannon*

4 **Investigations:** Steps toward an insulin pump, taking the measure of a cough.

5 **Explorations:** Using video to help adolescents overcome the stress of hospitalization.

45 **Communiqué:** Leadership in higher education. *Jon C. Strauss*

46 **Inside WPI:** Minority students ride WPI's COMET. *Denise R. Rodino*

47 **Memory Bank:** The history of the WPI seal. *Roger N. Perry Jr.*

48 **Final Word:** Two years on the roof of the world. *Amy Zuckerman Overvold*

Cover: Magnetic resonance imaging (MRI) technologist Terry Redgate scans a patient at Worcester's Biotechnology Park as WPI Professor Stephen C. Moore looks on. Story on page 12. Photo by Michael Carroll.

Staff of the WPI Journal: Publisher, Kenneth L. McDonnell • Editor, Michael W. Dorsey • Alumni Information Editor, Ruth S. Trask

Alumni Publications Committee: Samuel Mencow '37, chairman • Paul J. Cleary '71 • Judith Donahue, SIM '82 • William J. Firla. Jr. '60 • Maureen Sexton Horgan '83 • Carl A. Keyser '39 • Robert C. Labonté '54.

The WPI Journal (ISSN 0148-6128) is published quarterly for the WPI Alumni Association by Worcester Polytechnic Institute in cooperation with the Alumni Magazine Consortium, with editorial offices at the Johns Hopkins University, Baltimore, MD 21218. Pages I–XVI are published for the Alumni Magazine Consortium [Franklin and Marshall College, Johns Hopkins University, Villanova University, Western Maryland College, Western Reserve College (Case Western Reserve University), Worcester Polytechnic Institute] and appear in the respective alumni magazines of those institutions. Second class postage paid at Worcester, MA, and additional mailing offices. Pages 1–16, 33–48 © 1988, Worcester Polytechnic Institute. Pages I–XVI © 1988, Johns Hopkins University.

Staff of the Alumni Magazine Consortium: Editor, Donna Shoemaker • Wrap Designer and Production Coordinator, Amy Doudiken Wells • Assistant Editor, Julia Ridgely • Consulting Editors, Alan Sea and Elise Hancock • Core Designers, Allen Carroll and Amy Doudiken Wells.

Advisory Board of the Alumni Magazine Consortium: Franklin and Marshall College, Linda Whipple and Patti Lawson • Johns Hopkins University, B.J. Norris and Alan Sea • Villanova University, Eugene J. Ruane and D.M. Howe • Western Maryland College, Joyce Muller and Sherri Kimmel Diegel • Western Reserve College, David C. Twining • Worcester Polytechnic Institute, Michael Dorsey and Kenneth L. McDonnell.

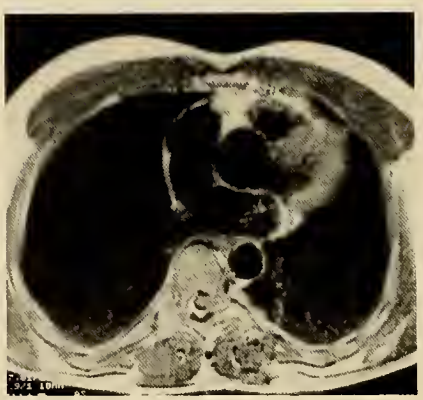
Acknowledgments: Typesetting, BG Composition, Inc.; Printing, American Press, Inc.

Diverse views on subjects of public interest are presented in the magazine. These views do not necessarily reflect the opinions of the editors or official policies of WPI. Address correspondence to the Editor, The WPI Journal, Worcester Polytechnic Institute, Worcester, MA 01609. Telephone (617) 793-5616. Postmaster: If undeliverable please send form 3579 to the address above. Do not return publication.

ADVANCE WORD

A Special Issue of *WPI Journal*: From Basic Science Comes a New Industry

It was just before midnight on July 3, 1977. In a laboratory at the Downstate Medical Center in Brooklyn, N.Y., Lawrence A. Minkoff '69 removed his shirt, slipped a cardboard vest wrapped with copper tape around his chest and sat down on a plank in the middle of a large circular magnet. Fighting fatigue and chill, Minkoff sat still for nearly five hours while radio signals scanned his chest. The result, pictured at right, was an amazingly detailed image of the structure of Minkoff's internal anatomy, the first human image ever obtained with a magnetic resonance imaging (MRI) scanner.



The first-ever MRI image: a cross section of the chest of Larry Minkoff '69.

By Michael W. Dorsey

Today Minkoff is executive vice president of FONAR Corporation. Founded by Raymond Damadian, a professor at Downstate with whom Minkoff did his graduate work in MRI, the company is a leading manufacturer of medical MRI machines. The technology developed by Damadian, Minkoff and other Downstate students is being used by thousands of doctors to detect abnormalities of the soft tissue, including multiple sclerosis and cancer. It is one of a host of revolutionary technologies—the products of basic research in biomedical engineering and biotechnology—that are transforming medicine, pharmacology and agriculture and giving rise to a brand new industry.

At its 120th Commencement exercises this spring WPI is paying tribute to this new industry. Among its shapers is Leo J. Thomas, WPI's 1988 speaker and one of four honorary degree recipients.

As senior vice president and general manager of the Life Sciences Division of Eastman Kodak Company, Thomas presides over a major research effort that may lead to whole new classes of drugs for use in the diagnosis and treatment of ailments of the immune, cardiovascular and central nervous systems.

The three other honorary degree recipients are also being recognized for their achievements in this new industry. They are Walter L. Robb, senior vice president for corporate research and development at General Electric Company; Gabriel Schmergel, president and chief executive officer at Genetics Institute Inc.; and Larry Minkoff.

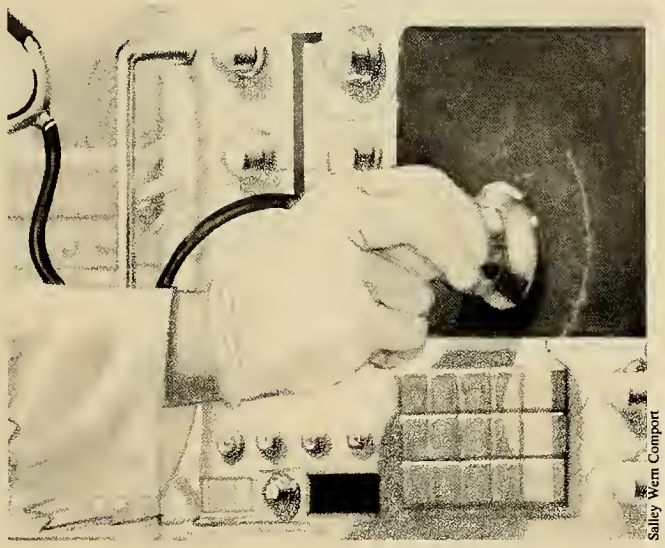
By choosing this commencement theme, WPI is acknowledging not only the amazing accomplishments of this young industry, but the role WPI has played in creating it. Several of WPI's faculty members, students and alumni have, through basic and applied research, played a role in the revolution that is transforming our world.

It is to these achievements that we devote the first 16 pages of this edition of the *WPI Journal*. You will read about several alumni whose work in biology and biomedical engineering has helped transform medicine. You will also find a profile of the Massachusetts Biotechnology Research Park in Worcester, a focal point for advanced research and state-of-the-art commercial applications in biotechnology.

Also included is a small sample of the wide variety of research and student project activity under way at WPI that is helping to fuel the new industry. In the laboratories of WPI's Biomedical Engineering Program, students and faculty are engaged in research in noninvasive medical sensors, medical imaging and cardiopulmonary physiology. Researchers in the Biology and Biotechnology Department are tackling fundamental questions in genetics, cell biology, molecular biology and neurobiology, and advancing such applied fields as cell culture, fermentation and bioprocess engineering. In such departments as Chemical Engineering, Electrical Engineering and Mechanical Engineering, work is under way in biochemistry, enzyme engineering, neurophysiology and biomechanics. And in WPI's Humanities Department, ethicists are exploring the implications of this revolutionary work on our society.

I hope you enjoy this special issue of the *WPI Journal*.

High-Tech Medicine: The Change from Caring to Curing


Salley Wern Comport

By Thomas A. Shannon

The science and practice of medicine have progressed dramatically in recent decades. Thanks to the discovery of vaccines and significant improvements in public sanitation, water quality and diet, diseases that were rampant even 50 years ago—polio, measles, mumps and smallpox—are essentially maladies of the past.

We have also seen a genuine revolution in health care and in the ability of physicians to intervene beneficially in the lives of their patients. In many ways this is a golden age of medicine. Or is it?

Despite the blessings of modern medicine, important questions are being raised about it, some focusing on its very successes.

For example, the progress we have seen in medicine has, in many cases, altered the relationship between physicians and their patients. Traditionally, most of us went to a single physician who attended to all of our health needs. While the "old-fashioned" family doctor has been romanticized, he or she did treat patients in a holistic fashion and was frequently as attentive to the psychosocial dimensions of a patient's life as the physical.

But while these physicians had a good "sense" of their patients, there was often little they could do for them because of the undeveloped state of medicine.

Things are different today. With the rise of HMOs, clinics and group practices, and with the increasing mobility of the population, Americans are less likely to be seen by the same physician over an extended period. They are also more likely than ever before to be referred to specialists who, despite their advanced training and competence, share no common history with their patients. When medical emergencies strike, patients can find themselves in the care of physicians they have never met before.

While today's physicians can usually "do something" for their patients, they may have little sense of the impact of such interventions on their patients' lives.

Another major change in medicine, also a function of specialization, is the shift from caring for patients to curing them. The job of the specialist is to administer a particular treatment, to perform a particular operation, or to deal with a particular disease or pathogen. His or her focus is on the disease and not the patient.

When the cure doesn't work—when the specialists' valued skills fail to bring about the desired results—physicians may be at a loss for what to do. AIDS is a particularly poignant example. While there is no cure for AIDS, its victims need exceptionally high levels of care. But those who are trained primarily to cure are often frustrated and unsure how to intervene when faced with patients for whom no cure is possible.

At issue is not whether these specialists are caring individuals; of course they are. But their training has focused on the techniques of curing rather than the skills of caring.

Contemporary medicine is also extremely costly. Bringing a new drug to market involves years and millions of dollars worth of research, testing and documentation. The introduction of new medical equipment can be even more expensive.

New drugs and equipment enhance the focus of modern medicine on curing illnesses or compensating for the loss of a patient's capacity. These goals have driven the development and use of life support systems, artificial organs, sophisticated diagnostic tools like magnetic resonance imaging and ultrasound, and high-tech treatments, such as the variety of devices used to unblock arteries.

But these technologies come into play only after a problem has developed. They are the product of a system dedicated to research and development, not prevention.

Certainly no single decision set medicine on this course. Still, high-tech medicine is more flashy, more impressive and more income-producing than the frequently boring and often frustrating efforts to help individuals change their lifestyles to prevent diseases from developing in the first place.

Yet a shift to preventive medicine would, in the long run, be less expensive. If a disease does not occur, one does not need to cure it. Clearly, more attention must be paid to the social context in which medicine is practiced before we plan the next generation of medical technology.

Dr. Shannon is professor of religion and social ethics in WPI's Department of Humanities.

INVESTIGATIONS

One step closer to an insulin pump

One of the dreams of researchers who study diabetes is to develop a closed-loop insulin pump, which could free many diabetics from the tedious daily routine of self-injection. But the development of such a device depends on finding a way to continuously monitor glucose in the bloodstream, since this information is essential for regulating the delivery of insulin.

While progress has been made on various insulin pumps, it will be some time before a reliable glucose sensor is ready, according to Robert Peura, director of WPI's Biomedical Engineering Program, and Yitzhak Mendelson, assistant professor of biomedical engineering.

With funding from the National Institutes of Health, Mendelson and Peura are taking a step toward that goal by developing a fiberoptic glucose sensor. The work is based on research they conducted over the past two years with WPI master's students Allen C. Clermont (who began the work as an undergraduate) and Been-Chyuan Lin.

Using a technique known as attenuated total reflection, they showed that it is possible to measure continuously the concentration of glucose in blood. The technique involves passing the beam of a carbon dioxide (CO_2) laser through a zinc selenide prism that is in contact with blood, and then analyzing the laser beam to see how much light of a specific wavelength the blood absorbs.

The next step will be miniaturizing this bench-top system. Mendelson and Peura say their goal is to develop a fiberoptic device made from the same material as the prism that can be inserted into the bloodstream through a catheter. The fiber will guide the carbon dioxide laser beam to the blood and then carry the reflected light back to an optical detector.

Mendelson says other researchers are working on glucose sensors, though most sensors use some form of chemical analysis, in which a chemical reaction with glucose causes a detectable color change.

"Our approach is unique in the sense that we are trying to avoid indirect detection," Mendelson says. "Instead of an intermediary chemical reaction, we are looking directly at the infrared absorption properties of the blood itself."

Though the long-term goal is to create a glucose sensor that can aid the development of a permanent insulin pump, Mendelson says a reliable glucose sensor may have more immediate use in monitoring diabetic patients and screening healthy individuals.

Allen Clermont (far left), Robert Peura and Been-Chyuan Lin with glucose sensor.

To catch a cough

Coughing is among the most common reasons people seek medical attention. It's also big business. Currently, pharmaceutical companies market 900 prescription and nonprescription products for controlling coughs. Over-the-counter cough suppressants alone accounted for half a million dollars in sales in 1981.

In spite of this, little is known about which medications, if any, truly control or eliminate coughing. The problem is that standard tests for cough medicines ask subjects to keep track of how many times they cough over a period of several hours. This self-reporting method is subject to significant error.

To help correct this, Frederick M. Bennett, assistant professor of biomedical engineering at WPI, and Dr. Richard Irwin, director of pulmonary medicine at the University of Massachusetts Medical Center, are at work on an electronic cough detector and counter.

Bennett and Irwin, in collaboration with WPI graduate student Thomas Webler ('87 M.S.),first studied the types of sounds that are associated with the physiological changes that occur during coughing. Using microphones placed at the trachea and the top of the sternum, they recorded coughs and other sounds made by several patients suffering from chronic coughing.

Because some of the sounds made during coughing are produced by the vocal chords in a process similar to speech, Bennett and Irwin analyzed the tape recordings with standard speech recognition software to see if these programs could discriminate between coughing and other sounds, including speech, made by the patients.

The results were promising, Bennett says. The next step will be to improve the algorithms in order to determine with greater accuracy the difference between coughs and speech, and to be able to recognize—perhaps even distinguish among—the wide variety of human coughs.

The algorithm will be tested on a large sample of patients at the University of Massachusetts Medical Center. The final step—still a few years away, Bennett says—will be incorporating the algorithm into a miniaturized device that can be comfortably worn by test subjects.

In addition to providing an unbiased method for assessing new cough formulas, a cough detector would also be a valuable tool for pulmonary physicians who need to know the frequency and severity of coughing in patients who suffer from chronic coughs. Such patients account for about 10 percent of all people seen by pulmonary specialists.

Project BODYWORKS: Using Interactive Video to Make Hospitalization Less Stressful for Adolescent Patients

Major Qualifying Project by James D. Goodell '87.
Advisors: James S. Demetry, associate head, Electrical Engineering Department, and Helen G. Vassallo, associate professor of management

Interactive Qualifying Project by Karen L. Reichenbach '88, Carleen F. Maitland '88, Natalie A. Lucas '88 and Joan Goodell of Worcester State College.
Advisor: Leonard Goodwin, professor of social science and policy studies

Sponsor: St. Vincent Hospital, Worcester, Mass.

A hospital stay can be an unpleasant experience for anyone. But for adolescent patients in particular, the hours spent confined to a hospital bed can be filled with frustration, fear, anger and just plain boredom.

Helping adolescent patients overcome the stress of hospitalization is the goal of Project BODYWORKS, a collaborative effort of students, faculty and staff at WPI, Worcester State College and St. Vincent Hospital.

Over the past three years, this consortium developed and tested an interactive videodisk program designed to be used by teenage hospital patients. Trials with the program confirmed that interactive video can indeed reduce stress and make patients feel more positive about their experience in the hospital.

Project BODYWORKS was the brain child of James Goodell '87. Goodell launched the program after another WPI undergraduate, Brian Witkowski '84, did a pilot study that showed that adolescents who played text-based computer games had a better attitude about hospitalization than those who spent their time with more passive forms of entertainment, such as television.

Michael Dorsey

Left to right: Seniors Karen Reichenbach, Natalie Lucas and Carleen Maitland.

While the games were effective, the patients, who were generally confined to bed, sometimes had trouble reading the text on a computer screen and were not able to type extensively on a keyboard. Goodell decided that an interactive video presentation that required a minimum amount of reading and typing would be a better solution.

He also recognized that producing such a program would take the talents and resources of many people. So he established the Project BODYWORKS consortium in 1985 to plan, produce and test a prototype video system.

Over the next 15 months, Goodell worked with a writer, a video producer and computer science students from Worcester State College; actors; and faculty advisors to create a program that uses a computer to merge video footage, sound, music, graphics and text into an interactive game.

The presentation was based on a concept of Dr. Sean Palfrey, chief of pediatrics at St. Vincent Hospital and a member of the Project BODYWORKS board of directors. St. Vincent also provided the funds for the program's production.

In Palfrey's program, adolescent patients play the role of a physician and attempt to diagnose the cause of a child's stomachache and fever. By using a touch-sensitive TV screen or typing simple commands on a computer keyboard, the patients can ask the child questions, do a physical examination and look up information in a "medical guidebook."

In response to the commands, a computer selects video footage or displays informational screens from a videodisk and merges them with titles and other text and graphics stored on the computer. The result is a simple story controlled entirely by the user who, after gathering sufficient data, asks the computer to verify his or her diagnosis.

The completed program was tested at St. Vincent Hospital by the team of Karen Reichenbach '88, Carleen Maitland '88, Natalie A. Lucas '88 and Joan Goodell, mother of Jim Goodell and an undergraduate at Worcester State College.

The evaluation team used a variety of questionnaires to gauge patients' feelings about hospitalization and their success with and opinion of the videodisk program. They even used biodots—small chemical thermometers that attach to the skin—to measure the patients' stress levels while they played the video game.

They found that the program does make patients who use it feel more positive and less stressful about their hospital stay, feel better about medicine in general and even develop better problem-solving skills. They declared the project a success, though they suggested further development of the video program and additional field testing.

This year, a new IQP team, working with Leonard Goodwin, will take on the task of expanding the testing program for the BODYWORKS videodisk. Another team, consisting of Philip A. Buttacavoli '88, Barbara J. Grimm '88, Daniel O. Olsen '87 and Karen E. Valentine '88, used the experience gained by the BODYWORKS team to complete a new interactive video program that simulates a chemistry laboratory taught at WPI.

The stories of five WPI alumni and how their careers have helped change the face of modern medicine

The Making of a Medical Revolution

By Michael V. Shanley and Paul Susca

IN THE LAST FEW DECADES, the practice of medicine has undergone a remarkable technological revolution.

Lasers that substitute for scalpels in delicate operations, machines that probe the interior of the body with magnets and radio pulses, scanners that use high frequency sound to monitor fetuses or detect heart ailments, devices that help the disabled overcome the limitations of their impaired senses, mobile intensive care units that can carry a hospital's emergency room to accident victims in the field—medical practitioners today have an arsenal of new and sophisticated tools with which to practice their art.

Here are stories of five WPI alumni who have made fundamental contributions to this medical revolution. This series was reported by Michael V. Shanley of Princeton, Mass., and Paul Susca of Rindge, N.H., both frequent contributors to the *Journal*.

Hearts Too Good to Die

A woman in her 20s is trapped, bleeding and gasping for breath, in the twisted wreckage of her car following a highway collision with a pickup truck. Rescue workers labor to cut away the mangled metal, but it may be an hour before she arrives at the emergency room.

A construction worker in his 50s suffers cardiac arrest on the job and falls off a scaffold, breaking his arm. His co-workers rush to begin CPR, but he doesn't respond well and is bleeding from his arm.

Thirty years ago the outlook for these two patients would have been dim, perhaps hopeless. Many victims of trauma and heart attacks—patients with very little actual damage to the heart muscle—were dying en route to the hospital because most people didn't know about CPR, and because ambulance crews were not equipped to recognize and treat heart problems and other life-threatening emergencies.

The situation has changed. For one thing, says Dr. John J. Gregory '53, we know more about heart attacks. And since heartbeat "rhythm disturbances" are better understood, doctors have available drugs and other treatments for getting the heartbeat back to normal. But even more important for such patients, who 30 years ago would have died in the ambulance, is the practice of taking intensive care "on the road."

Gregory directs the Cardiopulmonary Department at Overlook Hospital in Summit, N.J., in addition to its mobile intensive care unit (MICU) program. Overlook's program is typical of many worldwide: A pair of emergency medical technicians (EMTs), equipped with a van full of medical and communications gear, are in effect able to bring the hospital's intensive care unit to victims, stabilizing them before they are transported to the hospital.

Gregory was instrumental in shaping Overlook's program, which is equipped to defibrillate (apply electric shocks to the chest wall to get the heart back to its normal rhythm), support the patient's breathing, treat serious bleeding and begin IV therapy. On-site treatment by EMTs is completely under the direction of a specially trained physician at the hospital who keeps in constant radio contact with the emergency team. The radio hookup even sends the patient's electrocardiogram (EKG) directly to the hospital's emergency room.

Gregory didn't set out to specialize in emergency medical care. He studied chemical engineering at WPI, then worked briefly at Hurlbut Paper Company in his home town of Lee, Mass., before joining the Navy. After being discharged from the submarine service, he attended medical school under the GI Bill. Four years at Albany Medical College were followed by an internship, residency and cardiology fellowship at St. Vincent's Hospital in New York. Later, Gregory became assistant director of the hospital's Cardiology Department.

Co-author of the classic text *Cardiology: A Clinico-physiological Approach*, he has been involved in original research since his undergraduate days at WPI. As a medical resident at St. Vincent's, he participated in some of the early clinical work on the development of techniques for permanent pacemakers, and has conducted clinical work with pacemakers since then.

In early 1964, he was one of several St. Vincent's physicians featured in a *Life* magazine story that dramatized the pioneering work the hospital was doing with the resuscitation of heart attack patients. At that time, bringing someone "back to life" after heart stoppage was nothing short of miraculous.

Today he conducts research into the efficacy of various drugs used to reduce cholesterol levels and prevent heart attacks. And while he works to put mobile ICUs on the scene to save lives, he is also taking on the difficult job of helping doctors and families decide when not to resuscitate patients.

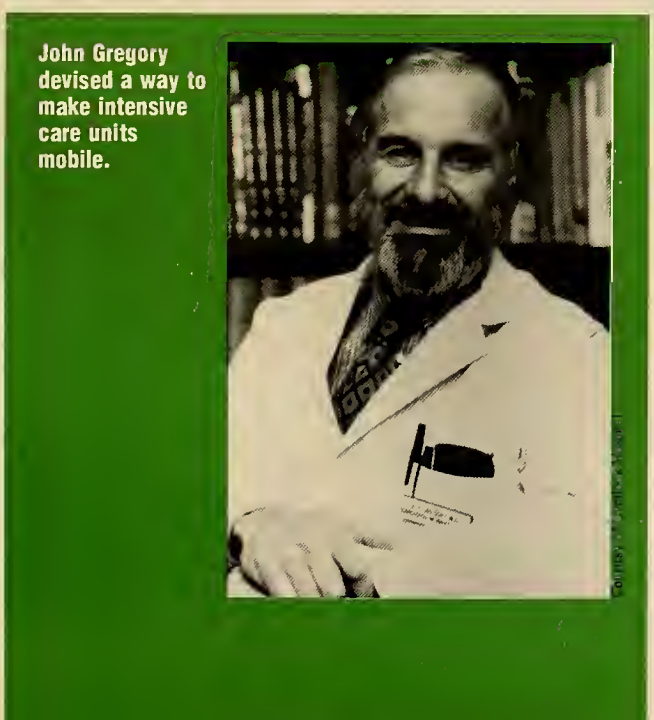
As a member of Overlook Hospital's bioethics committee, Gregory has studied the DNR (do not resuscitate) policies of other hospitals and drawn up guidelines to help doctors, in consultation with patients and their families, decide when a DNR order is appropriate.

"When [DNR policies] first started there were situations in which patients had been treated extremely vigorously and were living in ICUs [intensive care units]. The fact that life could be sustained and prolonged by the use of respirators and various other technologies is what brought the ethical questions to the forefront," Gregory explains.

So the rapid advance of medical and bioengineering technology has given rise, directly or indirectly, to the need for bioethics studies: "I think every hospital has to be very much involved in [bioethics] to be humane."

There is more to bioethics than deciding when to say "enough" when life in an ICU may be worse than an end to life. The monumental cost of state-of-the-art medical care and the issue of rationing care are also of great importance.

"Here's another area," Gregory says, "where the technology has improved the potential for care, and yet it brings about cost—and ethical—considerations that are very important." —*Paul Susca*



John Gregory devised a way to make intensive care units mobile.

High Tech for the Disabled

Larry Israel '61 couldn't have picked a better time to start his own company. After nine years at Xerox Data Systems, he raised some startup capital among friends and associates and, together with a neighborhood acquaintance, started a new company to manufacture electronic aids for the visually handicapped.

It was 1971, and the nation had not yet awakened to the plight of the disabled. But Israel's partner was a scientist who had conducted federally funded research at the RAND Corporation aimed at applying high technology to the problems of the disabled. He was interested in pursuing one of the results of that work—a system designed to help partially sighted people to read and write.

With Israel as the business and marketing half of the team and his partner as the technical expert, they took the plunge.

In hindsight, Israel scarcely realized how opportune his timing was. "There was really no such thing as a high-tech product for disabled people until about 1970 or 1971," Israel says. That was soon to change. People were beginning to see, he says, "that disabled people are entitled to be treated as individuals, not to be labeled and stereotyped and branded because of some perceived—and usually misperceived—characteristics attributed to the group."

The Rehabilitation Act of 1973 and 1974 "established principles of nondiscrimination based on disability that could be enforced in the courts," says Israel, who later studied law and is now a member of the California Bar. More importantly for his business, the act also provided money to help pay for products to aid the disabled in compensating for their disabilities.

Courtesy of VTEK

One of Larry Israel's "sensory-medical" devices helps partially sighted people read by magnifying type.

When Israel started Visualtek (now VTEK), much work still needed to be done on the device's read-write system. The RAND work, he explains, did not provide a specific system design, although it did demonstrate several key elements, among them the importance of a reverse image: white letters on a black background. It discovered that a moveable viewing table on which a book or paper could be placed was preferable to a moveable scanner or camera. And it demonstrated that 16 millimeter camera lenses were better than fixed magnification because they enabled the system to be more flexible.

Visualtek's first product, a read-write system comprising a video camera, monitor, moveable viewing surface and electronics for processing the image, was soon followed by a portable system. In the next 17 years, Israel's company sold about 30,000 of the systems to individuals, the Veterans Administration, state agencies, schools, libraries and nursing homes. They still had a long way to go: Of the estimated 500,000 legally blind people in the United States, 75 to 80 percent are partially sighted, according to Israel. "We suspect that at least half of them could benefit from our products, but there are other issues related to how motivated they are," he says. "For instance, many older people lose their sight after retirement and no longer have a need to use their sight for working."

Since their introduction, Israel says, VTEK's read-write systems haven't changed very much conceptually, but the company has added several personal computer peripheral devices for the blind and partially sighted. One is essentially a computer monitor with print that is five to ten times the usual size. Others include a braille printer and a "paperless braille" computer monitor. Today, Israel says, VTEK is the "world leader in providing electronic aids for the visually impaired."

Israel uses the term "sensory-medical" rather than biomedical to refer to his field, since the products don't affect or interact with biological functions.

That distinction is more than a semantic one. Sensory-medical products, he says, cannot be tested in the same way as most biomedical technology. Biomedical products can be tested using animals, for example, but sensory-medical trials have to involve people. "If you look at most biomedical testing," Israel says, "the human being who's going to benefit from it is a subject, rather than being a part of the solution to his own problem."

In addition to having a different relationship with the users of the products, the sensory-medical field also has a different relationship with technology, one that may put sensory-medical applications on less-than-equal footing with other biomedical developments. "The sensory-medical field doesn't get as much attention as biomedicine," Israel says "because there's not a clear marriage between the capabilities of technology and our human sensory mechanisms. The sensory mechanisms are among the most difficult areas of function for us to do something about."

But that certainly hasn't stopped Israel from making a successful business from sensory-medical products.

—Paul Susca

State of the Heart

■ It looks a little like the robot R2D2 of *Star Wars* fame, this Hewlett-Packard portable ultrasound imaging system.

And it's equally likeable and benign, helping as it does the elderly, the infirm and even the unborn.

As much as anyone, John Hart '65 has been responsible for bringing this product, which provides doctors with clear, accurate images of blood flow in and around the heart, to the marketplace. Hart, director of research and development for the HP Medical Products Group in Andover, Mass., oversees the efforts of 130 people who constantly refine and upgrade the imaging system.

So far, their efforts have clearly been a success. HP has more than 50 percent of the country's cardiac imaging business and about 40 percent of the business worldwide. Since its introduction in 1981, sales have grown by an astounding 50 percent a year.

The device that caused such dramatic change was slow to develop. "It took five years—and the equivalent of 100 R&D man years—to bring the system to market in 1981," Hart says. The system uses a variety of specialized transducers to detect even minute blood flow abnormalities. The original black and white model looks only at the heartbeat itself. As the system evolved, options such as Doppler capabilities (to detect blood velocity) and full color imaging were added. The colors allow doctors to make sophisticated determinations regarding such variables as flow direction, relative velocities and degrees of turbulence.

And that's just the beginning. "We keep finding new things to do with ultrasound," Hart says. "The information it's capable of providing is amazing. I can see where we can add a lot more things to this technology over the next five to 10 years. Color flow is really just starting, and beyond that I see 3–D and the ability to characterize the tissue in the heart and elsewhere in the body. It's possible to sort the ultrasound data to determine what class of disease a tissue contains."

A recently introduced HP system provides images of the carotids, the two great arteries of the neck. "If you have atherosclerosis, it's not only in your heart, it's also in your kidneys, and your arms and legs. It travels up to your carotids and into your brain. There's a strong need to find out if the vessels leading to the brain are occluded."

While the HP Medical Products Group's primary focus since 1961 has been cardiology, Hart says such fields as radiology, vascular surgery and obstetrics are seen as sources of potential new business. "We feel we can take the ultrasound technology into those fields and make a contribution there too."

The company's sale of medical products nationwide accounts for a little less than 10 percent of its overall $8-billion business. That $750,000 million or so represents the efforts of several related branches: ultrasound imaging, patient monitoring, diagnostic cardiology (EKG machines, for example) and obstetrical care.

In addition to managing the ultrasound imaging R&D effort, Hart is chairman of the R&D council for the entire medical products group. "It's my job to ensure that there's a synergy to the entire effort," he says.

Hart was recruited into the HP fold by Wilfred Houde '59. He had planned to get his master's at Yale, Hart recalls, but Houde convinced him to give HP a try.

"I hadn't even heard of HP at that time," Hart says, "but Wil convinced me. I signed on and they sent me to MIT to get my master's."

After working his way up from the HP lab, Hart was selected to form and then direct the ultrasound group when it began to take off in the mid-1970s.

Hart has now taken the recruitment effort full circle, serving as a member of the EE advisory committee and fostering the relationship between HP and WPI.

Returning to WPI, Hart found that EE Professor Reinhold Ludwig had an interest in ultrasound. HP is now sponsoring a dissertation at WPI aimed at furthering the development of new ultrasound transducers, which are a key element in the production of high-quality images. They are also complex and difficult to build.

"Dr. Ludwig and the doctoral student are working to improve the performance of the transducers," Hart says. "Then when we spend the million dollars or so it takes to build a new one, we can be sure we will advance the image quality. It's a breakthrough program, so we provide them with equipment and financial support. It's the kind of arrangement where both HP and WPI benefit."

—Michael V. Shanley

John Hart with ultrasound scanners undergoing testing. At Hewlett-Packard, Hart helped develop an imaging system that tracks blood flow to the heart.

Janet Woodcock

Where the Research Takes You

■ Dr. McCoy, the sympathetic physician on "Star Trek," could diagnose almost any ailment in seconds with his hand-held body scanner. Exactly how the device worked was left to the imagination, but today's biomedical technology may suggest to some that "Star Trek" medicine is not so farfetched.

Magnetic resonance imaging (MRI), developed by a team that included Larry Minkoff '69, already yields far more information about the body's internal state than physicians know how to use.

Versatility has been the key to Minkoff's contributions to the biomedical engineering field. In high school he built a closed ecological system in his basement in which algae produced enough oxygen to support a mouse—sealed in an airtight fish tank—for more than a month.

His undergraduate physics work at WPI focused on fish that use weak electric signals for sensing. His interest in biology then took him to the graduate school of the State University of New York's Downstate Medical Center in Brooklyn, where he went to work on a Ph.D. in biophysics and physiology.

Although there was a lab at Downstate involved in electric fish research, Minkoff became more interested in a problem posed by Dr. Raymond Damadian, a physician pursuing an unconventional theory about ion transport in living cells. The accepted view held that a "sodium pump" in the outer membrane of a living cell controlled the ion concentrations of the internal fluid by actively moving sodium ions out of the cell and potassium ions into the cell against their concentration gradients.

"When [Damadian] started studying ion transport in the cell, the question became, How are the ions bound within the cell? What holds them in there?" Minkoff recalls. His initial work with Damadian showed that the sodium pump was not thermodynamically feasible—in other words, cells just don't burn enough fuel to make a membrane pump work.

The next step was to show that the "structure" of water molecules inside the cell was different from that outside the cell. For this the Downstate team used a technique well known to organic chemists, nuclear magnetic resonance (NMR), which provides information on the chemical environment around the cell.

Since it was widely known that cancer cells contained more potassium ions than normal cells, Damadian tried applying NMR to the identification of these abnormal cells. It worked. From that moment, he was consumed with the idea of building a whole-body scanner that would use NMR to pinpoint and image cancers in human patients, a technique that came to be called magnetic resonance imaging (MRI).

Minkoff was very much a part of that quest. He obtained the first crude image of a tumor in a mouse, an image that was chosen to appear on the cover of the December 24, 1976, issue of *Science* because it resembled a Christmas tree ornament. Minkoff also served as the guinea pig when the research team created the first image of a human chest.

By collecting chemical information about the body, MRI can differentiate between normal and abnormal tissues, enabling doctors to identify tumors and other tissue alterations (hemorrhages, multiple sclerosis and so on) that could not previously have been detected in their early stages with other imaging techniques, including X-rays and CAT scans.

Larry Minkoff at FONAR Corp., the company formed to make MRI scanners.

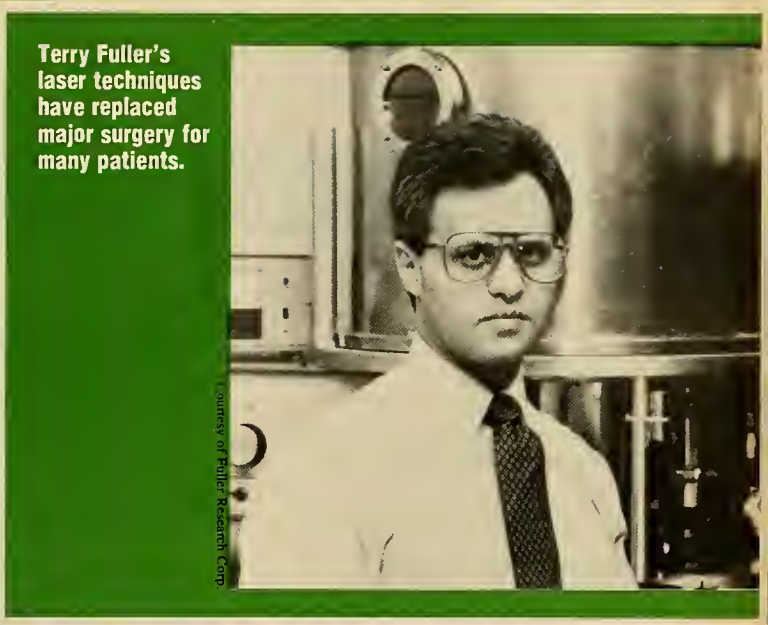
Today, as executive vice president and director of FONAR Corporation, the company that Damadian formed to manufacture MRI scanners, Minkoff is actively pursuing research at New York's Beth Israel Medical Center. He has already demonstrated the value of nuclear magnetic resonance in objectively detecting conditions like emotional depression and premenstrual syndrome. Minkoff's research, which may prove useful in evaluating treatments for those conditions, may be only the beginning of expanded diagnostic uses for MRI.

Minkoff sees automated diagnostic techniques like MRI becoming increasingly important in future medical practices. Some day, he says, a patient may be able to walk into a medical office and be scanned by an automated array of equipment that will then diagnose the problem and even prescribe treatment.

New medical technologies like MRI can help make diagnosis more accurate and efficient, Minkoff says, but their reliance on nonmedical disciplines like nuclear physics, electronics and computer science intensify the need for people with the multidisciplinary backgrounds.

Another argument for versatility, Minkoff says, is to be able to "go where the research takes you." The landmark success of the MRI team at Downstate was a consequence not only of their tenacity but of their ability to shift from cellular physiology to the engineering of a massive magnetic scanner—a gulf few scientists are able to bridge. —*Paul Susca*

Light over Scalpels



Terry Fuller's laser techniques have replaced major surgery for many patients.

■ Doctors at Sinai Hospital in Detroit had anesthetized a female patient for diagnosis of a reproductive problem that was causing infertility. By inserting an endoscope, an instrument used to look inside the body, they discovered that she had an adhesion that was blocking the Fallopian tubes.

Under normal circumstances, she would have been awakened, told of the condition and re-anesthetized so that the doctors could make a large incision and remove the adhesion. The result would have been a long hospital stay and a large bill.

"Instead, we made a minor incision, and used one of my experimental laser fiberoptic procedures to remove the adhesion right then and there," says Terry A. Fuller, president of the Fuller Research Corporation of Vernon Hills, Ill., a worldwide leader in the research and development of infrared transmitting fiber optics.

"In human terms, she was saved the trauma of major surgery and was home within 24 hours of treatment. In financial terms, our procedure cost about $1,500, versus the $8,000 or $9,000 it would have cost using traditional methods."

Fuller, who is considered one of the leading researchers in the field of laser medicine, developed many of the medical procedures that are being used in state-of-the-art laser surgery today. He holds one major patent with four others pending, and is the editor and co-author of the book *Surgical Lasers: A Clinical Guide*.

Among his many accomplishments was the introduction of what's known as an Nd:Yag laser to the treatment of uterine bleeding, which won him an award from the American College of Obstetrics and Gynecology.

Fuller's interest in laser medicine started at WPI, where he earned master's and doctoral degrees in biomedical engineering, the latter in 1975. He took that interest with him to Sinai Hospital, where he became involved in the use of ruby lasers to treat eye diseases.

In 1976, after winning a number of grants from the National Institutes of Health and other agencies, he formed the Laser Surgery and Photobiology Institute at Sinai. Over the next eight years, he turned it into the largest surgical laser facility in the world, both in terms of clinical procedures and research dollars.

He left the hospital in 1979 to form his own company, Medlase, which sold carbon dioxide (CO_2) and ruby lasers to the research and clinical communities. He also began developing fiber optics for use with CO_2 lasers. He was so successful that in 1984 he formed Fuller Research Corp. to commercialize the fibers. Fuller Research, a joint venture with Abbott Laboratories, a $4-billion health care company, developed the only fiber in the world that can transmit energy from a CO_2 laser through an endoscope.

Fuller says the laser "eliminates the need for a major incision to reach a diseased site in the body." For example, to remove a tumor inside the bladder, laser light can be directed along a fiber inserted through a cystoscope to vaporize the tumor. Thus far, that procedure has been used only on animals, and on humans only through a normal incision, but Fuller is gearing up for clinical use by the end of this year.

He believes that within five years there will be a $60-million-a-year market for devices that perform such procedures.

While laser surgery has become more widespread in recent years, the introduction of Fuller's new fibers will increase applications in such fields as gynecology, otolaryngology (ear, nose and throat), urology, orthopedic surgery and cardiovascular medicine.

Fuller Research currently operates with a staff of 17, including engineers in such fields as optics, materials engineering, physics, electronics, biophysics and mechanics. The company's 8,000-square-foot headquarters has optics, chemistry, fiber processing, electronics and polishing labs.

"Our intent right now is to expand our production capacity so we can meet the coming demand for these disposable fibers and for the fiber logic controller, a device that connects existing CO_2 lasers to our fibers so people don't have to go out and buy a new laser," Fuller says.

Later this year, Abbott Laboratories will be handling Fuller Research's initial market entry. After that, Fuller says, the company will be looking to expand the surgical applications of its fibers and, since they can detect heat energy as well as transmit it, exploring their use as sensing devices.

"My real love is clinical research," says Fuller, who still spends at least half his time in the lab. "I get turned on by the application of engineering and physics to medicine, and I really enjoy seeing my devices and procedures used in the way that they are."

Fuller remains on the staff of Sinai Hospital, as well as Ravenswood Hospital in Chicago, and is a faculty member at Northwestern University. He hopes one day to teach full time. "As much as I love industry—and the last four years have been the most exciting of my career—I really miss the frequent contact with grad students."

—Michael V. Shanley

By Michael V. Shanley

Biotechnology Meets the

The founders of the Massachusetts Biotechnology Research Park wanted to build a vehicle that would cruise into the 21st century—under its own power.

Michael Carroll

Worcester dentist Abraham Haddad was a driving force behind efforts to build the park.

It's an impressive list of acronyms: MBRI, MBRP, WBDC, MCEC, CBI and, in the middle of it all, WPI.

The Massachusetts Biotechnology Research Park is off and running, but unless you're involved in the action, you'll need a scorecard to identify all of the players.

What the list of names and letters adds up to, however, is a unique biotechnology venture. With its combination of city, state and federal support; profit and nonprofit agencies; and commercial and educational goals, the park is an example of what can be accomplished when disparate groups with common interests band together to battle the forces of bureaucracy, skepticism and the status quo.

What many called an unrealistic dream now consists of one gleaming research laboratory/office building (with a second under construction and a third on the drawing board), a fully operational Magnetic Imaging Center and, under construction, a hotel that will house a restaurant, retail space, a bank and other business services.

But more impressive than the real estate development, more impressive even than the willingness of premier start-up companies to cast their lot with Worcester, is the extraordinary cross-fertilization of ideas that is taking place. It's what science and engineering are supposed to be all about. The Biotechnology Park is truly a visionary enterprise, a testimony to the foresight and perseverance of a diverse group of Worcester residents. And from the beginning, WPI has been a part of the effort.

To understand what the park is today, it's important to go back to the beginning and hear the story of the park that could easily have died, but simply wasn't allowed to.

"The park is the brainchild of the Worcester Business Development Corporation (WBDC), an arm of the local Chamber of Commerce," explains Abraham W. Haddad, a Worcester dentist credited by many as being a driving force behind the park effort. (Other key figures include John Hunt and Paul O'Connell, each of whom served as WBDC president, and Wyman Gordon chairman Joseph Carter.)

It all began, Haddad says, when a blue-ribbon panel of community leaders from business, politics, health care and education convened in the early 1980s to look at the role Worcester, with its diverse industrial base, 10 colleges and universities, several research and teaching hospitals, and 35,000 students might play in the science and technology of the future.

The panel, whose members included former WPI president Dr. Edmund T. Cranch, unanimously agreed to pursue the establishment of some sort of research park.

It's no coincidence, Haddad notes, that colleges and universities nationwide jumped on the technology transfer/innovation center bandwagon seven or eight years ago. "It was about then that the licensing and patent laws changed regarding federally funded research." The changes enabled researchers and their institutions to participate in royalties and licensing agreements with fewer restrictions.

"So when we approached the Worcester institutions, there was a definite electricity in the air, because they realized the opportunities," he adds. The WBDC then committed its resources to strategic planning and self-assessment. Representatives from the panel visited research parks throughout the country. They realized that, since their park would be smaller than many, they would have to find a niche. Given the strengths of area institutions in the life sciences, biotech-

Perpetual Motion Engine

nology was the obvious choice.

"We zeroed in on the University of Massachusetts Medical Center as the hub," continues Haddad, "with research institutions like WPI, the Worcester Foundation for Experimental Biology, Tufts University Veterinary School, Clark University and Holy Cross as spokes."

When organizers began to look at common interests, they were surprised to find that area businesses, hospitals and academic institutions were already conducting between $70 and $100 million worth of research.

Haddad and others came to realize that one ingredient was missing: neutral ground where scientific entrepreneurs could come together to share expensive equipment, pursue industrial liaisons and apply their research. While Worcester was moving ahead with its agenda, Massachusetts Governor Michael Dukakis was in the process of establishing the Massachusetts Centers of Excellence Corporation (MCEC) to maintain the state's competitive edge in emerging technologies. Because of Worcester's groundwork, it became the focus of the state's biotechnology efforts.

This tie-in became crucial as the Worcester Business Development Corporation began to pursue ownership of the proposed site for the park, a choice 100-acre tract of surplus state land adjacent to the Medical Center. The land was owned by the center and Worcester State Hospital, but the governor's office worked to transfer ownership for a nominal sum.

It was a long, tiring process, one that presented the proposed park with its first major obstacle when the trustees at the State Hospital filed a lawsuit to block the transfer. Worcester State lost the suit, but the battle dragged on for more than two years.

Despite the delays, WBDC had been proceeding with its plans. "We decided to create several magnets to attract companies here," Haddad explains.

The major magnet was to be a state-of-the-art shared instrumentation facility for new companies that couldn't afford to buy expensive equipment. The second would be an incubator that would provide hands-on management and scientific consulting.

"We realized that with biotechnology you couldn't just go into a garage and come up with a new company, like you could in the '70s with computers," Haddad says.

Another magnet that was already in place was the Worcester area itself. With its research institutions, affordable housing, central location, cultural offerings and fine school systems, Worcester could hold its own in the competition to lure new firms.

Also among the attractions was a City Council-approved set of regulatory ordinances based on NIH guidelines. While other cities and towns were tying researchers' hands with confusing and constraining ordinances, Worcester established a set of clear-cut, up-to-date regulations.

The cornerstone of the Worcester effort was a desire to create what Haddad calls a "perpetual motion engine." "Money would continually be re-infused into the system, and that's vital, since the technology changes so quickly."

This concept was the beginning of the Massachusetts Biotechnology Research Institute, the non-profit board set up to oversee the scientific and intellectual development of the Park. MBRI members include representatives from area research institutions (including WPI's president, Dr. Jon C. Strauss), the Chamber of Commerce and local businesses.

"From viewing other research parks, though, we found that a key to survival was going proprietary early on," continues Haddad, who is now president of the MBRI board. "So while we originally wanted to keep it all nonprofit, it was driven home to us that an intense entrepreneurial posture was only possible by adding a for-profit element."

So were planted the seeds of what is now Commonwealth BioVentures Inc. (CBI), a company that combines the financing of a venture capital firm with the management resources and low-cost rental space of a business incubator. CBI is largely owned by MBRI. In return for its services, Commonwealth BioVentures takes a percentage of the start-up companies being funded.

The state helped establish CBI, in the

Janet Woodcock

President Jon Strauss predicts WPI's ties to the park will increase.

Stretching the Limits of a New Technology

AT THE FAR END OF THE ROOM sits a six-foot-tall magnet that looks for all the world like a massive mechanical doughnut. A student slides a "phantom" that simulates a human brain into the magnet's cavity and, like iron filings under the pull of a child's horseshoe magnet, atomic nuclei in the phantom align with the magnetic field.

Twenty feet away, a researcher types a command on a computer keyboard. Inside the magnet, pulses of high frequency radio waves probe the phantom. With each pulse, the magnetized nuclei absorb the radio energy, then relax, sending radio waves back to receivers in the magnet's cavity.

From this subtle interaction of magnetic field, radio waves and "brain," a computer assembles and paints on a high-resolution monitor a detailed image of the phantom's internal structure.

The technique is called magnetic resonance imaging, or MRI, the latest and most powerful imaging technology available for medical diagnosis. At the Massachusetts Biotechnology Research Park's Magnetic Imaging Center, Stephen C. Moore, associate professor of biomedical engineering at WPI, and Dr. Michael A. Davis, a researcher in the Department of Radiology at the University of Massachusetts Medical Center, are stretching the limits of MRI.

Unlike conventional X-ray machines and CAT (computerized axial tomography) scanners, which use penetrating radiation to probe the density of the body, MRI employs a combination of a powerful magnetic field and radio signals to produce amazingly detailed images of the body's soft tissues.

"MRI is much better than conventional X-rays at detecting soft tissue lesions," Moore says. "While CAT scanning did make it possible to better visualize some of the subtle differences between soft tissue, the sensitivity of MRI is generally much higher. For example, MRI can easily detect multiple sclerosis plaques, something that is more difficult with CAT."

MRI can also reveal a great deal about the chemical and electrical states of the atoms and molecules in the body's tissues—information that can help radiologists locate tumors and other abnormal types of cell growth.

With a research team that includes four WPI graduate students and six undergraduates, Moore and Davis are looking for ways to improve a host of medical imaging systems, including MRI, nuclear medicine and more conventional X-ray techniques.

One of the projects currently underway is aimed at using MRI to measure noninvasively the velocity of body fluids, such as blood and cerebrospinal fluid.

Michael Carroll

Stephen Moore (left) and Michael Davis

The team will also study ways to compensate for image artifacts that are produced by certain types of tissue and to improve the signal-to-noise ratio in MRI images, making it easier for physicians and technologists to see the vital information they contain.

In another project, Moore and Davis are evaluating a new class of bifunctional chelates made by Viomedics Corporation, a Biotechnology Research Park tenant, that may make tumors stand out more clearly on MRI images.

Despite their rapidly evolving research efforts in MRI, Moore and Davis are relative newcomers to this imaging technique. Davis, who earned his bachelor's and master's degrees in chemistry from WPI, launched the collaboration in 1987 when he convinced the state of Massachusetts to obtain a research magnet for the proposed MRI center at the Biotechnology Park. WPI is currently providing the space in the center for a laboratory and hired Moore, an expert in such medical imaging techniques as nuclear medicine and CAT, to develop a research program from within the college's Biomedical Engineering Program.

This summer, the laboratory will move into a new research wing at the imaging center. The new space will include a chemistry and electronics laboratory and offices. In this expanded laboratory Moore and Davis will continue to test the limits of MRI, a technique which may be capable of telling physicians more about the state of the human body than any other diagnostic tool now available.

"There is still a lot of unexplored territory in MRI," Moore says. "The promise may prove to be more than the reality, but I think there's a lot more to be discovered about this technology."

sense that the Massachusetts Centers of Excellence Corporation financially supported the MBRI effort to develop a vehicle for technology transfer. "Again, we were trying to meld private, industrial, state and academic interests. It was a delicate operation," says Haddad.

CBI, which really got under way last year, was the final Worcester magnet.

In the spring of 1986, construction began on the Park's three-story, 75,000-square-foot first building, One Biotech Park.

"WBDC had lined up a consortium of 10 banks that provided construction and land development financing," explains Raymond L. Quinlan, MBRP executive director and the man in charge of attracting tenants and overseeing construction. "The city had provided off-site improvements, and the state eventually awarded us a $1-million grant to fund on-site improvements."

WBDC had millions of dollars invested in the project, but no tenants yet committed. A deal with Integrated Genetics fell through when the Fra-

mingham firm decided the building wouldn't be ready soon enough to suit their needs.

Making matters worse, an expected $1 million grant from the federal government kept being delayed.

While the WBDC's public posture was one of confidence during this period, Haddad admits it was a trying time: "We always believed in what we were doing, and that we would ultimately be successful, but there were a few cliff-hangers."

The story, of course, had a happy ending. Late in July 1986, Cambridge BioScience Corporation (CBC), a highly respected medical products firm, signed an agreement to lease 50,000 square feet of space. Not surprisingly, CBC chairman Gerald F. Buck cited several of the Worcester "magnets" in explaining the firm's decision.

A few months later the park had its second major tenant when Viomedics, Inc., a start-up company concerned with new approaches to the treatment and diagnosis of such diseases as cancer and arthritis, signed up for 6,000 square feet.

With the ice broken and more inquiries coming in, plans accelerated. In the late summer of 1986, construction began on the Magnetic Imaging Center, a project run by a nonprofit consortium of Worcester hospitals. Soon thereafter, design work and marketing began for Biotech Two, the second laboratory building. At the same time, plans were announced for the hotel complex.

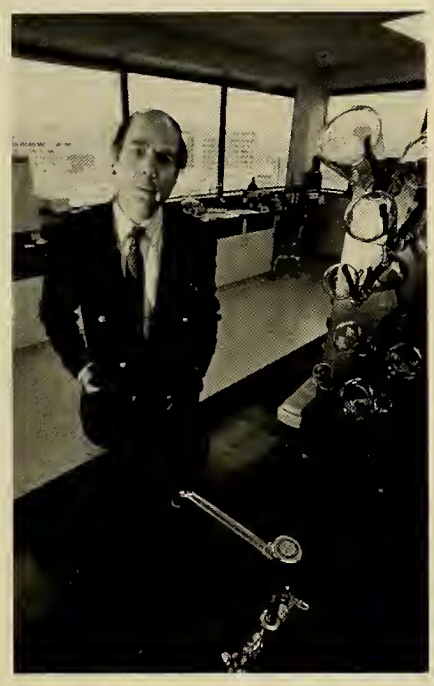
Today, all the acronyms are thriving. CBC has completed clinical trials on a five-minute antibody test kit for AIDS. Pending FDA approval, the company plans to introduce the test commercially later this year. Work also continues on development of an AIDS vaccine, as well as on other products that detect and prevent human and animal infectious diseases. Several WPI graduate students have spent time working at CBC.

CBI, under the leadership of Robert G. Foster (hired following a nationwide search headed by President Strauss), has established its $5-million limited partnership to invest in new biotechnology companies over the next year. (WPI is the only institution to invest as a limited partner.) The first company to receive financing is Transgenic Sciences, Inc., which will conduct research into producing disease-resistant poultry and, ultimately, into the application of transgenic technologies to the treatment of human genetic diseases.

"Nowhere else is there such concentrated research in biotechnology."

Massachusetts Centers of Excellence has provided about $500,000 in grants to MBRI for personnel, facilities, shared equipment and program operations. MCEC also provides direct grants to researchers throughout the state.

The Magnetic Imaging Center is in its second year of operation. It houses both a diagnostic clinic and a research facility that use magnetic resonance imaging (see sidebar).



Michael Carroll

Spiros Theodoropulos founded Viomedics, which became the park's second tenant.

Viomedics continues its research into diagnostic reagents to be used in the treatment of diseases. Among current projects are the development of new imaging techniques for various organs, and therapeutic drugs for the treatment of rheumatoid arthritis and tumors. Company founder Spiros Theodoropulos has established ties with the MIC and WPI biology and biotechnology chairman Joseph Bagshaw.

If the concern was once whether or not there would be enough tenants to fill the park, the problem now is meeting the demand.

"We figured it would take us 10 years to complete the park," says Quinlan. "But we're well ahead of that timetable. If we have a problem, it's that things are happening too fast. Biotech Two is almost completely 'called for,' so we've hired an architect to begin design on Biotech Three. It's a pleasant problem to have, but it is a problem."

The WBDC's magnets notwithstanding, there is another reason why Worcester is attracting firms.

"Nowhere else is there such concentrated research in biotechnology," says Quinlan. "Scientists have to stay current, especially in this field. And to do that, they need to be part of a research environment, and have access to academic institutions."

Haddad notes the wide scope of area life science research. "We have every level of research applications in the human life sciences, from the molecular level to animal resource facilities to the human populations at the hospitals."

Now that CBI is up and running, MBRI has redefined its role. In addition to being Worcester's representative in all matters concerning the park, it also operates a nonprofit innovation center that supplements CBI's efforts.

"When a scientist simply has an idea and needs the space and the funds to pursue it, that's where MBRI will come in," says Haddad. "It's a homegrown approach, because we anticipate that some of these ideas will spawn start-up companies that will one day be housed in the park."

Adds Quinlan, "Right now, most of the money coming in goes toward paying off our debt and funding future growth. But at some point three or four years down the road, the park will begin to show significant profits—maybe $3 or $4 million a year—and that money will be invested back into the efforts of scientists through MBRI."

This is part of the perpetual motion engine the park's founders had foreseen. And while the engine is still being put together, it's already beginning to purr. MBRI has awarded its first grant—to WPI biology and biotechnology Professor Daniel Gibson (see sidebar).

"There's no doubt that our ties with the park will increase," says President Strauss. "As the park and CBI mature, the rewards will flow through MBRI, and there will be more grants like the

one Dan has. In addition, our faculty will be involved with the companies being seeded by CBI."

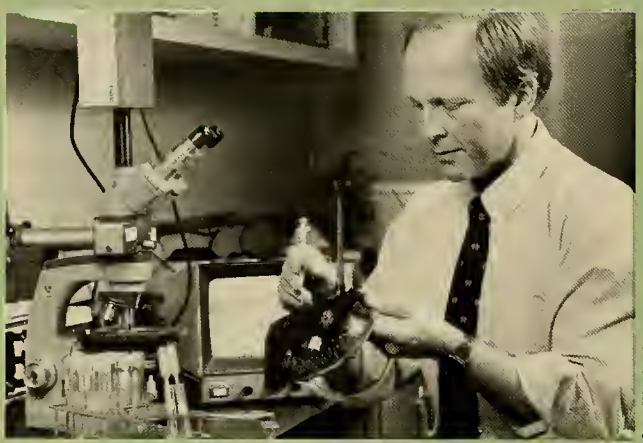
As Haddad looks to the future, he too is upbeat, and refers again to the perpetual motion concept. "By the year 2000, there may be a new technology, and the park will shift its emphasis. That's why we've fought to maintain an R&D attitude. We want the park to constantly regenerate itself, replenish its occupancy, spin out people to satellites in other parts of the state where there are mature manufacturing levels."

While plenty of dollars have changed hands as the project has gotten off the ground, it was unpaid work that actually created the park—the hours of free labor and brainstorming donated by Worcester scientists, educators, community leaders and businesspeople as they nudged it from dream to reality.

They rolled up their sleeves to put this engine together, and they can take tremendous satisfaction in watching it hum down the highway, picking up speed with each passing mile.

Mike Shanley is a frequent contributor to WPI Journal.

Modern Science Meets the Living Fossil



Janet Woodcock

Daniel Gibson extracts blood from a horseshoe crab.

IT IS ESTIMATED that horseshoe crabs have been quietly foraging along the New England coast for 225 million years. Only recently have these ancient relatives of spiders encountered a serious threat to their existence.

Today, along the beaches and marshes of Cape Cod, they are killed by clam diggers, who see them as competition, and chopped up by eel fishermen, who say they make excellent bait. And in the laboratories of a small Cape Cod company, scientists collect their blood.

It was just a decade ago that researchers discovered a remarkable property of horseshoe crab blood. When exposed to any sort of gram-negative bacteria, amoeba-like cells in the blood set off a clotting process that rapidly turns the crab's blood to jelly. This primitive immune response helps the crab seal off wounds and ward off bacterial infection.

Because the blood cells react to all gram-negative bacteria—a class of microorganisms that cause a significant share of human ills—they can be used as an excellent probe for the presence of bacteria in medical devices, including dialysis machines, and food processing equipment.

The largest use, however, is in the screening of injectable drugs for bacterial contamination, where the only alternative is testing with rabbits, a much more expensive procedure.

Associates of Cape Cod now makes a powdered extract from horseshoe crab blood called LAL (Limulus Amebocyte Lysate). To make the extract, the company collects blood from large, mostly female crabs in the spring when they come ashore to mate.

After they are bled, the crabs are returned to the ocean, apparently without harm. Still, since bleeding began, scientists have observed a significant drop in the horseshoe crab population off the Cape. The cause of this decrease is not known, according to Daniel Gibson, associate professor of biology and biotechnology at WPI. While the impact of the clammers and eel fisherman, along with natural population fluctuations, cannot be discounted, the long-term effect of removing the often egg-laden crabs from their natural environment during the breeding season is not well understood.

That is why Gibson has been working with a team of undergraduate and graduate students on a method of culturing the blood cells of the horseshoe crab in the laboratory. Last year, Gibson received a $20,000 grant from the Massachusetts Biotechnology Research Institute, the first grant ever awarded by this research arm of the Massachusetts Biotechnology Research Park, to continue this work.

If a stable culture can be developed, Gibson says, the makers of LAL would have a year-round supply of blood cells without the need to bleed crabs. This hope has fueled many efforts over the last decade to culture the blood cells. About four years ago, Gibson tried to duplicate the results of some apparently successful efforts only to discover that what most, if not all, of these researchers had grown was not blood cells but a form of marine yeast.

Through trial and error, Gibson was able to establish a stable culture of amebocytes, but he could not get the cells to grow and divide. He decided that the solution was to culture not the cells themselves but the tissue that manufactures the blood cells—the crab's "bone marrow."

Working with teams of undergraduate students completing their Major Qualifying Projects (MQPs), Gibson began the hunt for this tissue, which had not previously been identified. He developed a method in which dissected crabs are infused with antibodies that have an affinity for the crab blood cells. Next, a second antibody, one that clings to the first antibody, is added. Attached to this second antibody are tiny balls of gold. Under an electron microscope, the gold balls serve as beacons, highlighting the exact position of the blood producing cells.

While initial work with this method was under way, Gibson, working with an ordinary light microscope, observed what appeared to be the blood-cell-producing tissue. He extracted the tissue and was able to get it to grow. Further work will be needed to see whether the new cells in the culture will mature into LAL-producing blood cells.

In the meantime, Gibson is talking with Commonwealth Bioventures Inc., the Biotechnology Park's incubator, about the potential for turning the results of his research into a new company.

Lessons from not long ago

Courses on recent history offer controversy, context, and a challenge: teaching contemporary events to students who know little of the past

BY JULIA RIDGELY

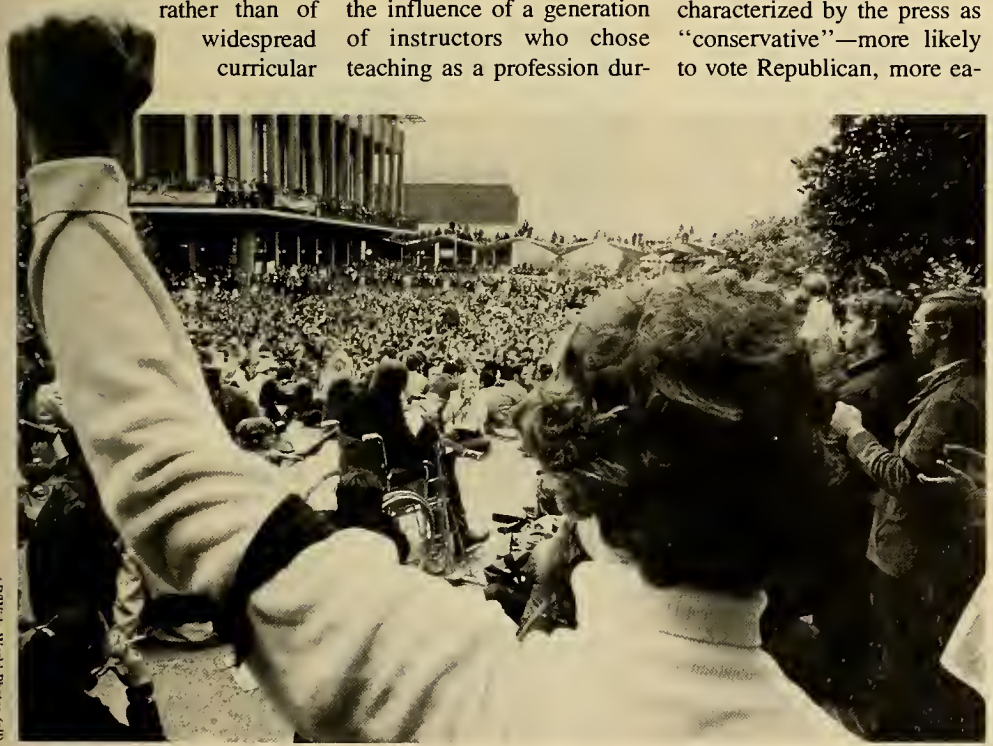
When Neil Armstrong walked on the moon on a summer Sunday in 1969, American television viewers were vividly aware that they were witnessing a thrilling milestone in history. So they may be momentarily surprised to learn that their children and grandchildren perceive that triumphant event as little more than a grainy photograph in a textbook. They may wonder, too, when their offspring ask, "What was it like to live in the '60s?"

More students are posing that question, partly as a result of college history courses that teach and interpret recent events. While such classes are still mainly products of the interest of individual teachers rather than of widespread curricular changes, their popularity among students who are often poorly grounded in history of any era shows that the courses are having some success. And the courses show the influence of a generation of instructors who chose teaching as a profession during the '60s, and who regard the study of recent events as a chance to pass on a sense of social and democratic responsibility.

Today's students have been characterized by the press as "conservative"—more likely to vote Republican, more eager to join the corporate establishment, less willing to take an activist stance. In the classroom, that conservatism can translate into a passive attitude toward events and a disapproving, even hostile, view of social change.

To these students, "the world started the day they became conscious of being a human being, maybe when they were 14," says Patrick Dunn, professor of history at Worcester Polytechnic Institute (WPI). "Anything outside their narrow range, or what happened before then, has no bearing today." As a result, Dunn has great difficulty with this group in presenting the '60s as a period of social transformation. "They don't recognize what society was like before the '60s," he says. "I try to get at it by contrasting what WPI was like then—a preplanned curriculum, Saturday classes, suits and ties, no women on campus. They don't realize that the society they live in now is something vastly different; they just take it for granted that it was that way and will always be that way."

Such an attitude is upsetting to teachers both as historians and as shapers of citizens. Teaching recent history



AP/Wide World Photos (all)

Images from the Vietnam era—a B-52 raid (1966) and a Berkeley rally in memory of students killed at Kent State (1970)—haunt a generation. Yet "for the current undergraduate, the war has become another historical event, like World War II," says CWRU's Morrell Heald.

What history books have concluded about their own times

HOW LONG does it take historians to decide what events are important and what they mean? On the following pages are passages from histories written within a few years of the events they cover. They are seen through the filter of the interests, obsessions, and prejudices of each period.

gives them the opportunity to show students that the relationship between individual behavior and history is ever-evolving, a responsibility the teachers treasure.

Recent history—roughly the period after World War II—is not just a valuable area of study in itself, but a way of promoting interest in history as a whole. Christianna Nichols is an instructor in political science at Western Maryland College (WMC) who teaches a class in modern and contemporary European political movements, including those of the Soviet Union. "The enticement," she points out, "is that the course sounds modern, and suddenly all this stuff in *TIME* about *glasnost* and *perestroika* is going to come to life." But then, she notes, "People in my class will ask, 'Why are we talking about Czarist Russia in the 12th century?' " and that gives her the opening to talk about the panorama of events across the centuries.

There will always be misty areas in any adult's memory where the lessons they've studied in history books leave off and the awareness of the era they've lived through begins. And there are generational differences between those who grew up in the shadow of overwhelming events—the Depression and World War II—and current students, born in the late '60s, whose world may seem to be a more diffuse collection of influences. Teachers praise in today's students what they see as a global perspective, a greater awareness of the diversity of culture. Television has tremendously aided that wider outlook. "I didn't have a world view growing up," says Albert Dorley, assistant professor of history at Villanova University. "What came over the television were cute shows. I wasn't watching the war in Vietnam in living color."

The availability and vividness of worldwide TV news is still no competition, however, for the profound impact great events have had on those who lived through them. "The generations of the '30s and '40s had the experiences of the Depression, which formed a drive toward a unified national identity, and World War II, which brought about the highest level ever of national unity," says Lou Athey, professor of American history at Franklin and Marshall College (F&M).

By contrast, the events of the last 40 years are a bewildering catalog of crises—social, political, international, and economic. The longing for a common generational experience may explain, in part, the baby boomers' current fascination with the 1960s as they search for a cultural identity in one of the most contradictory of decades.

The knowledge gap of current students stems not just from how much there is to know about the present but from how little they know about the past. Without background—a sense of history as a story, with identifiable plots, subplots, and themes—they have no context in which to place recent events. A common complaint of teachers is that their charges are bright and hardworking, but lack their parents' firm foundation of historical narrative and facts.

Two trends in the 1960s and '70s help explain the mystery of the weakened foundation. One was the expansion of the curriculum to include more than the traditional "great white men"; the other, a new emphasis on teaching practical "skills" rather than names, dates, and places.

Few would dispute the value of the former. Traditional survey approaches, such as the "presidential synthesis" of American history, stressed politics and war, dividing the centuries into precise four-year chunks of "events." But for the first time, revised curricula added the stories of women, Afro-Americans, American Indians, and immigrants, as well as social and cultural movements. American history became more complete, but also more complex.

Some teachers are concerned that in the great variety of themes and perspectives, crucial facts and a sense of the sweep of history may have been lost. Students "aren't drilled and disciplined as to historical process, time bars, what occurred when, the sequence of events—all that is compressed and confused," says Villanova's Dorley. "There might be a bit of overstressing of social and cultural events, taking society as a whole rather than looking at changes and developments."

But most teachers are equally critical of the "back-to-basics" method popularized by, among others, Allan Bloom (author of the best-selling *The Closing of the American Mind*). Lowell Gustafson, assistant professor of political science at Villanova, calls it a "cafeteria approach." "There is no agreement on broad and sweeping issues," he says. "It's kind of a computer-age version of what cultural literacy is. It reminds me of my high-school history teacher filling the

WPI's Patrick Dunn must challenge students' preconceptions when he teaches about the Soviet Union under Stalin. "Somewhere they've gotten this idea that he was paranoid," he says. And they want to cling to it, even after Dunn's detailed lecture on Stalin's objectives and Soviet politics of the period. No matter if students get sketchy information from textbooks or TV, Dunn says, "the point is to make sense of it for ourselves."

blackboard with names from Hammurabi to Nixon; if we could identify them all, then we supposedly knew something about the forces that shaped history."

In the '60s and '70s, "it became very fashionable to focus on questions," adds Con Darcy, professor of history at WMC. Texts of the period badgered student readers with "topics for discussion" as a way of engaging student interest: "What do you think an average merchant would have thought about the Declaration? A wealthy landowner? An artisan?" More recent texts, Darcy believes, divide history into specialized parcels at the expense of necessary information: "You look at a textbook and there's a paragraph given to Lincoln and a paragraph to Woodrow Wilson. These little units on 'The Women of the Second World War' are fine, but let's have that in addition to the basic story."

The minds of many older Americans are attics in whose nooks and crannies the artifacts of their national history are stored away: carpetbaggers, Teapot Dome, the Mayflower Compact, the XYZ Affair, Manifest Destiny. But to many contemporary students, it's all a jumble; their trunks have never been filled with history's treasures. At WMC, Nichols has only been teaching college for a few years, but notes that since her days as a graduate student the "lack-of-background" problem has been getting "incrementally worse and worse. You assume they know about intellectual currents, and they don't."

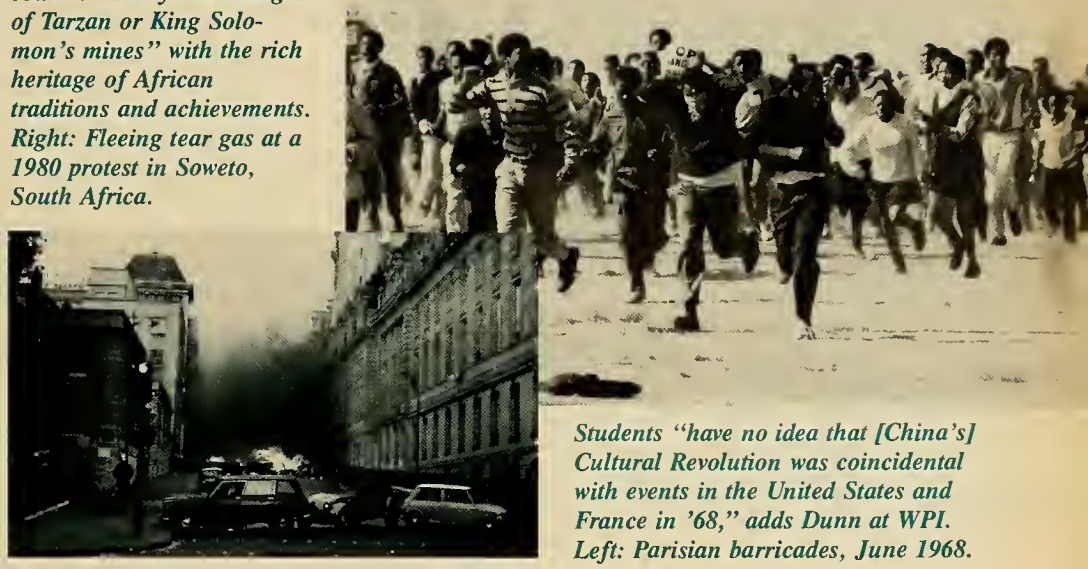
The approach emphasizing "life skills" at the expense of presenting history as part of an engaging narrative has come under special criticism from the chair of the National Endowment for the Humanities. Lynne V. Cheney, in the 1987 report *American Memory*, wrote about how in the teacher's guide to a popular textbook series, "Scores of skills to be taught are set forth: everything from drawing conclusions and predicting outcomes to filling in forms and compiling recipes." Yet, she emphasizes, "The cultural content of learning, on the other hand, is given only brief mention."

Focusing on recent history can be valuable in capturing the attention of students who in high school were turned off to history in general. Those who have no strong feelings about the Civil War may at least gain a sense of the importance of the war in Vietnam. Villanova's Dorley, for example, says students sign up for his popular Vietnam course because "their parents were there, or their parents are still talking about it. The war is still a very big issue because of its impact on domestic and foreign policy."

Teachers of recent history welcome the opportunity to fill in the knowledge gaps of their students, even though the effort is time-consuming. When Nichols talks to her Western Maryland class about changes in the Communist Party since 1917, she runs back and forth between blackboards, one of which has a diagram of the system in 1917, the other the current one. "You have to constantly tie them together," she says. But she admits, "it would be much easier if the basic history knowledge were there. In my Latin American class, we have to go back and talk about Incas and Aztecs before we can talk about terrorists in Peru."

Lack of background among today's high-school students is an equally serious problem for teachers throughout the humanities. Assistant Professor of English Kent Ljungquist offers a survey course in

Political turmoil and famine in Africa have drawn students to Con Darcy's class at WMC, where he tries to counter "Hollywood images of Tarzan or King Solomon's mines" with the rich heritage of African traditions and achievements. Right: Fleeing tear gas at a 1980 protest in Soweto, South Africa.



Students "have no idea that [China's] Cultural Revolution was coincidental with events in the United States and France in '68," adds Dunn at WPI. Left: Parisian barricades, June 1968.

Reconstruction (1865–77): "The scandal of the system grew insufferable"

POLITICAL RECONSTRUCTION was carried out according to the plan of Congress. . . . Ostensibly the negro was master of the States; but his utter ignorance, incapacity, and credulity made him the dupe and tool of white adventurers from the North, nicknamed Carpet-baggers, who, in alliance with some apostate Southern whites, nicknamed Scallywags, got the Southern governments in to their hands. . . . At last the scandal of the system grew insufferable, military protection was withdrawn from the carpet-bagging governments, which fell, and the whites were enabled to reinstate themselves in power. They did not fail practically to disfranchise the negro. . . . So it is still. The negro at the South enjoys, as a rule, personal and industrial rights which the war won for him, but is excluded from political power. From social fusion and equality he is, if possible, further than ever, since concubinage has become rare, and there is an end of the kindly relations which sometimes subsisted between master and slave . . .

The United States, An Outline of Political History, by Goldwin Smith (1893).

Desegregation: "So drastic a social revolution"

THE MOST MOMENTOUS action on a domestic problem was taken not by Congress or the President but by the judiciary. The Supreme Court ruled unanimously, on May 17, 1954, that the long-established "separate but equal" school facilities granted to Negroes violated the 14th Amendment. The Court fortunately indicated that so drastic a social revolution as desegregation would have to be worked out gradually. Dixieland hotheads violently resented this invasion of states' rights, but most Southerners showed a disposition to grapple with the problem slowly and sanely.

The historic decision of the Supreme Court was widely hailed as the greatest victory for the Negro since Emancipation. An intermingling of the races had already occurred with unexpected success in the armed services. Now destined for the schools, it would lift from the Negroes the psychological blight of being set apart as creatures inferior. The United States could henceforth hold its head up more proudly as the Land of the Free, and give the lie to Communist agitators who insisted that America was committed to holding the Negro perpetually in the ditch.

The American Pageant, by Thomas Bailey (1956).

American fiction at WPI. In it, he tries to "teach novels almost as case studies of the way in which certain political developments were transformed into fictional terms. Ten or 15 years ago, you might not have had to do that because you might have taken it for granted that the students had a reservoir of historical knowledge to call upon."

Ljungquist has found that the most popular works remain those that, like J.D. Salinger's *Catcher in the Rye*, stress timeless themes of individual experience and growing up. He has had less luck with novels like *Going After Cacciato* (in which Tim O'Brien works fantastic, fictional variations on the Vietnam War) or even those that assume familiarity with the mood or culture of an earlier decade. "Especially with so many writers of the '60s and '70s, popular culture becomes part of their fiction," Ljungquist says. "In Updike novels, people watch TV; he'll be writing about a person observing a particular historical event, and if the students don't know what that event is, then obviously there's a difficulty getting across what Updike's up to."

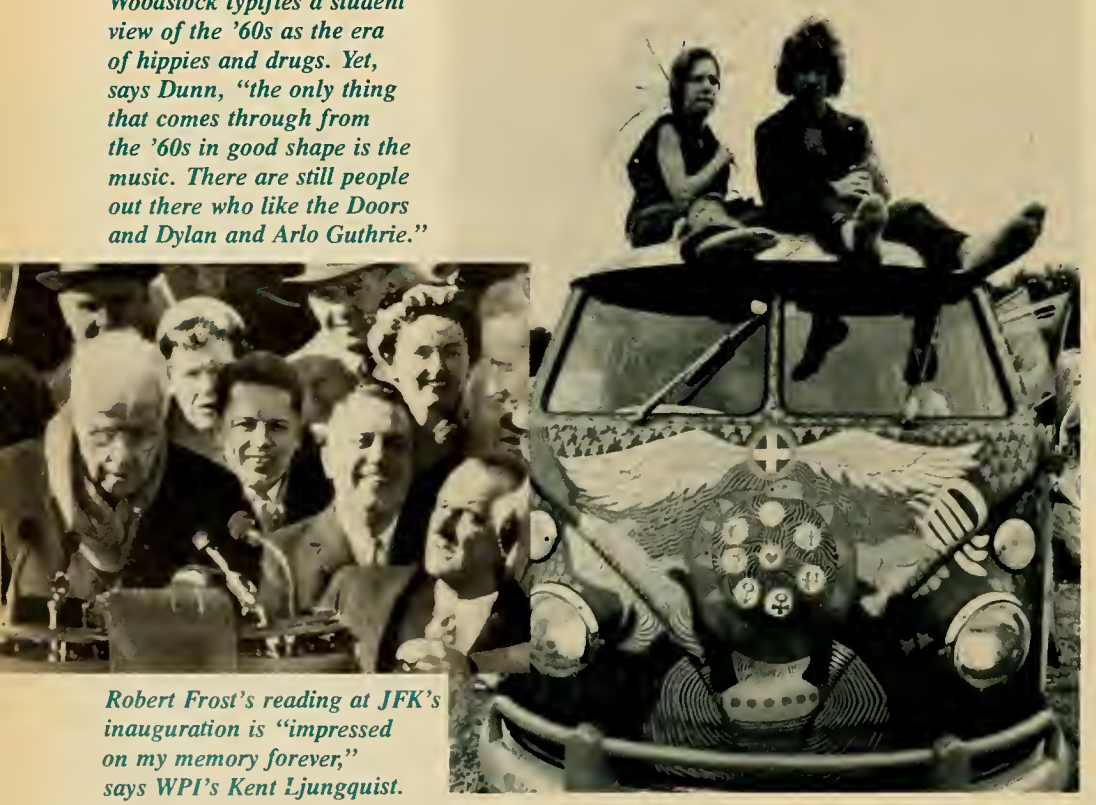
Teaching fiction does provide a chance, however, to raise political and moral ideas that students might otherwise resist. "If you teach an essay that has a polemical point to it, the student won't accept it. But if you teach a novel that has pretty much the same point or theme behind it, then suddenly they approach the subject with a greater degree of flexibility," Ljungquist says.

Park Goist, professor of history at Case Western Reserve University, teaches a class on social values in recent American drama. He believes that drama, even more than fiction, provides a level of engagement that helps students overcome their prejudices. "It's specifically American material," he says, "but it raises eternal moral questions."

Some courses turn up again and again in catalogs, either because they respond to areas of current national interest (Latin America, Africa, the Middle East) or because they are of perennial concern (the Cold War, U.S.-Soviet relations, racial and religious issues). Often, the most current topics are found in the political science department, since the discipline relies in part on analyzing systems rather than on making historical judgments. "In comparative politics, we have models of Communist systems or European systems," says WMC's Nichols. She teaches about Great Britain under Margaret Thatcher, for example, because Thatcherism "has been around almost 10 years, is a definite movement, and has radically altered the system."

The problem for historians is in deciding what trends or events from the infinitude of a particular year or decade are the significant ones. Many people can remember from their own textbooks what now seem like ludicrous oversights or predictions; only hindsight is able to select the little streams that become rivers. A 1966 text, *Contemporary America*, emphasized the economy, labor conflict, the Cold War, and civil rights as the major themes of the '60s. Vietnam receives a brief mention under the heading of "brush fires" around the

Woodstock typifies a student view of the '60s as the era of hippies and drugs. Yet, says Dunn, "the only thing that comes through from the '60s in good shape is the music. There are still people out there who like the Doors and Dylan and Arlo Guthrie."



Robert Frost's reading at JFK's inauguration is "impressed on my memory forever," says WPI's Kent Ljungquist.

Take out a blank sheet of notebook paper . . .

How many of the following names, quotes, and events look familiar? There are five terms from each of the last four decades of American history. Extra credit: How close can you get to the actual year each event happened? Answers on page VII.

1. the Great Society
2. Apollo-Soyuz
3. "We're eyeball to eyeball . . ."
4. the safety net
5. SCLC
6. Gramm-Rudman
7. Gulf of Tonkin
8. 444 days
9. the great silent majority
10. Proposition 13
11. U-2
12. SALT II
13. PATCO
14. "I have here in my hand 57 cases . . ."
15. the Warren Report
16. 38th parallel
17. "There you go again."
18. Little Rock Central High School
19. CREEP
20. Bikini Atoll

world, and the chapter ends rather optimistically with a description of President Johnson's "New Society" programs. But within a few years, black urban neighborhoods had erupted into violence, Vietnam had become a full-fledged war, and Johnson's reforms has been upstaged by even more radical social and political movements. By 1977, the text *The National Experience* devotes an entire chapter to the 1960s as "Years of Revolt," stressing themes of alienation and social conflict and tracing the history of America's gradual entanglement in Southeast Asia.

Even within the '70s, events are beginning to sort themselves into piles of either the anecdotal or the significant. President Carter's pardoning of Vietnam War draft dodgers, a major event of the time, is now largely forgotten, while his failure to secure the release of U.S. hostages in Iran—a political disaster that may have influenced the 1980 election—is now viewed more as a failure of personality than of policy. What Christianna Nichols' political science students are learning about Carter are the sweeping effects of his human rights policy, which contributed to the fall of several Latin American dictatorships.

Since views of events change so quickly, how can historians presume to teach about those not yet sorted out? The problem is probably no worse than in the discipline of history as a whole. Yet someone who 40 years ago studied U.S. history—learning of presidents, politics, and wars—would find today's survey courses astonishingly different, encompassing decades of progress in teaching social history through such topics as slave culture, the women's suffrage movement, the effects of immigration, or the history of the family.

But teachers of contemporary history don't claim to be handing down the definitive view of the events they cover. While highly praised textbooks already exist on topics like the Vietnam War, courses on contemporary history rely on a tremendous variety of source materials, among them, newspaper articles, first-person accounts, tapes, and oral narratives. WMC's Con Darcy introduces his class to contemporary African culture through African-produced films. Morrell Heald, professor of American studies and history at CWRU, brought to his class a graduate who is a Vietnam vet and a counselor of fellow veterans, and another speaker who heads a Cleveland Vietnamese organization. F&M English Professor Anthony Ugolnik has students interview and profile Vietnam vets and takes the class on a field trip to the Vietnam Memorial in Washington, D.C. WPI's Dunn gives his students readings from the diaries of American soldiers who intervened in the Russian revolution in 1918.

Such materials introduce an intensity and interest far beyond the reach of textbooks and, with it, a problem: point of view. "I think it's essential that the students learn to analyze critically any book or article, whether it's on the left or the right," says WPI's Dunn. "I run into a problem in that the best textbooks in Russian history, and some of the best on Cuba, are written by émigrés who have a far-right opinion. Then, some of the best stuff on Iran is written by American critics on the left. I don't teach my students that any of these is the definitive interpretation."

Wildly divergent points of view can be disquieting to students raised on committee-approved textbooks. "So many come to college after reading these Dairy Queen homogenized products," says Darcy. "Some of them are going to react very strongly."

"I use the diary of a person who lived in Cuba during the Castro years," says Villanova's Gustafson. "One day I said that I liked a lot of what

The 1960s: "Cults appeared among the young"

MOST BORN AFTER 1940 spent their childhood under relatively comfortable circumstances. . . . Life in the child-centered suburb was undemanding and defined the important goals in terms of good performance in the schools. . . . The prospect of the inadequate and unworthy challenges of the life ahead was distasteful to boys and girls starved for affection, who felt themselves lone wolves remote from everyone else. . . .

Childhood in the slums, and particularly in the Negro ghettos, lacked the ease and comfort of the suburbs and often lacked also the guidance of close family life and the discipline of the father. An upbringing like that of Malcolm X in such an environment quickly generated hostility to society, and the furious aggressions of adolescence found few legitimate channels of expression. . . .

From time to time cults appeared among the young, centering upon some symbol that indicated repudiation of authority—James Dean in the movies, Mickey Spillane in the pulps, or the Beatles on records—saying no to the solemn nonsense of the rulers of the world. Eccentric styles of behavior or dress flouted convention so widely in the 1960s that they themselves became conventional, and the uniform of the Beatnik was everywhere recognizable.

The History of the United States (textbook), by Oscar Handlin (1968).

was discussed in the book but didn't like this or that. Many of the students had a shocked expression that a professor would be so silly as to disagree with a book he had assigned."

Professors also run into two very different types of prejudices that students bring with them to the classroom. The first—preformed political opinions—is often welcomed. "People come to my class with a rather hardened and enthusiastic position that is not particularly well-informed," says Gustafson of his course on Latin American politics. "That's an advantage of teaching the type of course I teach. For whatever reason—because they despise American policies or they despise the Sandinistas—they come motivated."

Teachers sometimes even wish for more dissension than they get. "I was a little puzzled by their attitudes initially," says Heald of the students in his Vietnam course. "What brought them to the class was that they had been hearing about the war for years and didn't really know much about it. They didn't see it as a controversial subject. With one or two exceptions, there were not strong views expressed; none at all on the pro-war side. What they showed was quiet curiosity."

Villanova's Albert Dorley cautions that "history has parallels, but it doesn't repeat itself." Right: near Saigon, 1967.

Criticized for his handling of the economy and the Iran hostage crisis, President Carter is cited in Christianna Nichols' WMC political science class for his diplomacy in Latin America. Left: Carter with Brazilian President Ernesto Geisel in 1978.

The second kind of prejudice students harbor is more dangerous: a perspective of history as a constantly improving, organized sequence of events in which the United States is always a force for good. "I think they have a very linear view, and see anything that deviates from that as being caused by drugs or hippies or weirdos or revolutionaries," says Dunn. "Their main line of thought is that things are getting better, and if they're not, it's because people don't act in the proper way.

" I see it more in the international arena: Students might be thinking, 'If people in Africa would work hard and think rationally like us, everything would be better.' "

F&M's Lou Athey adds that this attitude is not just true of history: "Our students also assume a kind of inevitability of technological progress. When you transfer that construct to social issues, there is a belief that clearly everything will be solved in time. We live in the modern age, with the assumption that this age is better than any other time."

History teachers—especially those who concentrate on the past few decades—see such complacency as one of their main targets. Their hopes for success may depend on what many report as an ambivalence among students toward social change, epitomized by current student attitudes about the 1960s. While their parents are caught up in the nostalgia of TV programs like "The Wonder Years," students are wrestling with two very different views of that decade: one, that it was a hippie-dominated era of drugs and dropping out; the other, that it was a time of great excitement and involvement, one they might have enjoyed experiencing. Often the student who passes up political activism to study hard and get into business school is the same one who rummages in her parents' basement for Dylan records and tie-dyed shirts.

Lou Athey has taught an oral history course in which he focuses on a different 10-to-15-year period each semester. When his class studied the '60s, he says, "there

The Vietnam War: "Prolonged propaganda wears out the credit of governments"

THE UNITED STATES WAS ABLE to wage a war halfway around the globe. But officially it could not tell its own people the truth. As the war dragged on, the Saigon government became more and more dictatorial. . . .

So the statement that we were "defending democracy" in Vietnam became even more hollow. Yet American officials continued to repeat that plainly untrue statement. Prolonged propaganda eventually wears out the credit of governments with their own people. And the armed forces, too, once considered guardians of honor, fell into the habit of untruthfulness. Time and again, officials would announce that the government now controlled most of the countryside and that there was a "light at the end of the tunnel."

. . . . It was small wonder that the average soldier, the "grunt" at the bottom of the heap, became demoralized. He was fighting a war against an invisible enemy, was surrounded by what seemed to him ungrateful "natives," and was criticized by many war protesters at home. He was led by generals who often seemed interested only in image making, not in protecting him. By the thousands, therefore, soldiers in Vietnam took drugs, dodged regulations, and disobeyed their officers. The war was beginning to destroy the American army by 1968.

Pathways to the Present:
A New History of the United States (textbook),
by Bernard A. Weisberger (1976).

were students who wanted to discount the hippie experience as having been a minimal factor" in the social change the decade produced. He sees the reaction as part of an "absolute and utter rejection of critiques of existing social structures." When he assigned a class *Looking Backward, 2000-1887*, Edward Bellamy's 1888 novel describing a future socialist utopia, he says "half the class was furious at it. One paper attacked it and used language not proper to a paper." Yet at the same time, he has had students express great interest not only in the '60s but in the Civil War. "It's the intensity of involvement and conflict between the two nations, the very high level of commitment, that interests them," he says. "I think many would like to have lived then."

Particularly for instructors educated in the '60s, the interest shown by students in current history provides an opportunity to challenge, if not change, students' complacency. "As long as students, and people in general, don't explore the last 20 years, they tend to take the pronouncements of authority as fact. Rarely does a leader deliberately mislead," WPI's Dunn believes, "but if people haven't critically examined these events or cultural trends, then there's no basis for them to question what they hear. Then what do democracy and freedom of the press mean?"

Of his teaching, Dunn says, "There's some evidence that there is an impact. The way I look at it is that I have one shot at it; that's what I came here for. If I can see a visible change, a sensitivity and a willingness to entertain possibilities—that's the best I can do."

Julia Ridgely is assistant editor of the Alumni Magazine Consortium.

Answers

There are no grades for this test, just some excuses: How well you did probably has less to do with how hard you studied in high school than when you were born or how you were taught history.

1. President Johnson's term for a package of social and welfare programs, including civil rights and aid to the poor and elderly. (1964)

2. Docking of American and Soviet spacecraft in the first international manned spaceflight. (1975)

3. ". . . and I think the other fellow just blinked." Comment made by Secretary of State Dean Rusk during the Cuban missile crisis. (1962)

4. Reagan administration term for programs that would save the "truly needy" from budget cuts. (1981)

5. The Southern Christian Leadership Conference, the civil rights groups founded by the Rev. Martin Luther King, Jr. (1956)

6. Congressional act to force federal budget reduction, later struck down in part by the Supreme Court. (1985)

7. Gulf where North Vietnamese torpedo boats were said to have attacked American warships. The resulting resolution by Congress granted the president whatever power necessary to "maintain peace." (1964)

8. Length of time 52 American hostages were held in the embassy in Tehran by Iranian revolutionaries demanding the return of the Shah. (1980–81)

9. Middle-of-the-road Americans whom President Nixon claimed had elected him and continued to support him. (1971)

10. California property tax referendum considered an opening volley in the tax-cutting movement. (1978)

11. American spy plane shot down over Russia. Pilot Francis Gary Powers was later exchanged for a Soviet spy. (1960)

12. Strategic Arms Limitation Talks at which President Carter and Soviet Premier Brezhnev agreed to a limit on ICBMs. The U.S. Senate refused to ratify the treaty after the Soviet Union invaded Afghanistan. (1979)

13. Professional Air Traffic Controllers Organization. The entire membership was fired when President Reagan enforced a law against unionization by federal employees. (1981)

14. Sen. Joseph McCarthy's claim in a speech at Wheeling, W.Va., that he had evidence of 57 "known Communists" in the government, the first time he had emphasized such a claim publicly. (1950)

15. The report of the President's Commission on the Assassination of President Kennedy, concluding that Lee Harvey Oswald had acted alone. (1964)

16. Border between North and South Korea. After North Korea invaded across the line, President Truman ordered in U.S. troops, the beginning of U.S. involvement in the Korean War. (1950)

17. Remark made by presidential candidate Ronald Reagan in the campaign debate with President Carter. Reagan believed his opponent had just misrepresented his views on national health insurance. (1980)

18. Arkansas high school where President Eisenhower sent federal troops to enforce integration over the objection of Gov. Orval Faubus, who had called out the state's National Guardsmen. (1957)

19. The Committee to Re-Elect the President, President Nixon's campaign organization later accused of being behind the Watergate burglary. (1972)

20. Pacific island destroyed during the first hydrogen bomb test. (1956)

Answering machines, VCRs, and processors of food and words are designed in part to save time. But how do we spend all those seconds we saved?

HOME SLEEK HOME

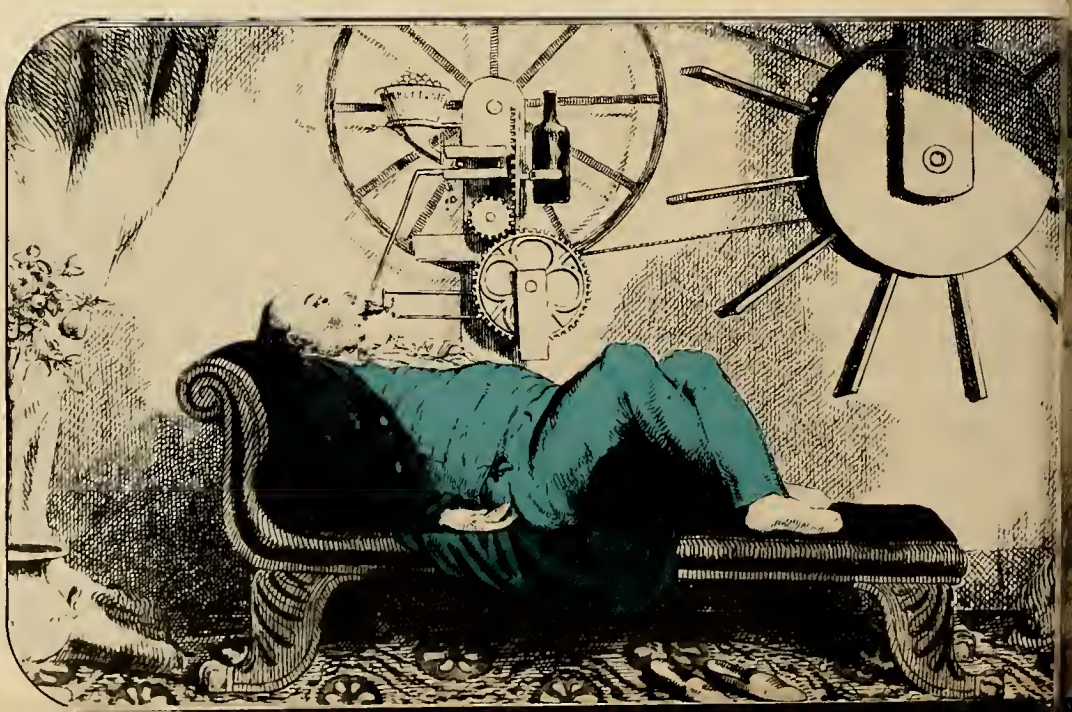
BY MARY RUTH YOE

Back in the summer of '72, when only three in a hundred American homes boasted a microwave oven, a friend extolled the marvels of his new culinary appliance. "I cook dinner in 10 minutes—a baked potato, too," he crowed, "then I sit back with my remote controls and watch my TVs."

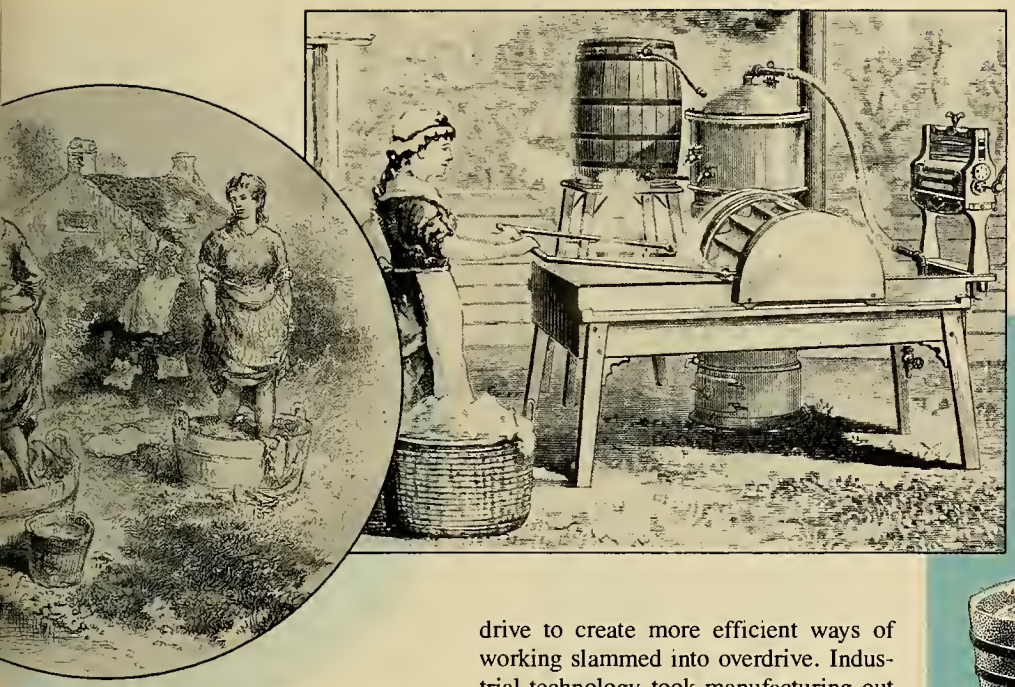
"TVs?" I asked. He had three in his living room, one for each of the major networks. During commercials, he sampled other channels: "I hate to waste my time."

The man was—just slightly—ahead of his time. Today, two in three American homes have microwaves. And televisions equipped with split-screen capabilities end what one catalog calls "the frustration of single-channel viewing." Ours is a nation dedicated to the proposition of saving both time and our own energy, at work and at home. It's only human: "To save labor in work and in the many other activities of daily living has been the supreme aim and proud achievement of modern civilization," wrote Stanford University economist Tibor Scitovsky in *The Joyless Economy*. "The saving of effort," he went on to note, "usually goes hand in hand with the saving of time."

In a certain sense, you can't save even a second. In the annual phenomenon known as daylight-saving time, an hour snatched away from the public each spring is returned, without interest, six months later. But it's more nearly day-



The modern age is hardly the first to worship efficiency. In this 1880s scheme, the urge to expand the day, reduce work, and slip in more leisure time is taken to an extreme: The device offers relief from summer's heat by simultaneously fanning the body, cracking nuts, and serving wine.



The chore of laundry, originally hand-and-foot powered, was made easier by machines and then was taken out of the home altogether—for those who could afford it.

light-withholding time. Every day, no matter what your time zone, everyone gets exactly the same number of hours to spend. Meanwhile, time marches on.

Which is why the 45 minutes you "save" by popping a potato into the microwave instead of an oven can't be added to your personal account at the First National Bank of Hours. It can't sit there, quietly earning additional minutes, or even seconds, until the happy day when you finally have the energy, but need to borrow the time, to embark on a long-planned project. In real life, the time you save doing one thing goes immediately into doing something else—or nothing else.

Timesavers have always been with us, although some have worked better than others. Start somewhere near the beginning of civilization, with roughly shaped bits of flint—the multipurpose gadgets of the Stone Age. Then fast forward thousands of years to the city of Pompeii. In its post-Vesuvius ruins, archaeologists uncovered housewares, including vegetable strainers and shallow pans for frying. Except for their handcrafted bronze construction, they would be at home in a contemporary kitchen.

Zoom ahead again, this time to the Industrial Revolution, when the human drive to create more efficient ways of working slammed into overdrive. Industrial technology took manufacturing out of the home and into the factory, separating production from "housework." (The word itself didn't appear until the 19th century.)

Suddenly the mechanics of daily living—tasks that had required essentially the same amounts of time and effort for centuries—were transformed. By the first years of the 20th century, most urban homes in the United States had tap water. Indoor plumbing was gaining ground, along with electricity and central heating. Unpredictable stoves fueled by wood or coal gave way to gas models; electric ranges would be next. Telephones, vacuum cleaners, electric irons, and rudimentary washing machines had appeared. Refrigerators were about to become less expensive and more reliable.

Inventions didn't always make common household tasks easier. According to a study published in 1917, almost all women living in households "earning enough for decency" had help with their laundry, either sending it out or bringing a laundress in. But what had been a two-woman job became relegated to one. While the advent of the automatic washing machine did take the back-breaking labor out of doing laundry, it also meant families could have more clothes, washed more often.

In an industrially driven society, each new household invention, from irons to bagel slicers, added to the already strong climate of expectation that time can—and should—be saved.

Americans bought that message, and in increasing numbers, they also purchased the items, from major appliances to minor gadgets. A few examples: In 1952, less than 4 percent of American homes had clothes dryers; by 1984, 61 percent did. In 1952, 3 percent had dishwashers; in 1984, 38 percent. During the 20 years ending in 1975, the percentage of homes with vacuum cleaners went from 59 to 97 percent. More people were buying smaller appliances—blenders, food processors, automatic coffee makers, electric can openers. The consuming continues, fueled by promises of "new, improved" variations.

Some of the improvements are more gimmicky than genuine—shaving off the odd second here and there rather than doing away with a truly onerous task. Or they perform superfluous jobs. An electric ice-cream maker churns out a gourmet treat in minutes, but when you buy

Baskin-Robbins, you don't have to clean the machine—which, unlike your bowl and spoon, probably can't be popped in the dishwasher.

Then there's the multi-speed electric blender. When the first model reached the market in the 1920s, it had just one speed ("on" as opposed to "off"). In the 1950s, the two-speed ("high" vs. "low") blender appeared. A decade later, the liquidizer wars began in earnest. By the early '70s, the victorious models had 16 "speeds," although an industry executive would later admit, "At most there was a 100 rpm difference between one speed and another—virtually indistinguishable." But as another executive pointed out, "The more buttons, the better they sold."

Other devices don't always live up to the promise of their ads. Look at food processors. More than half make their way into kitchens as gifts, according to *Consumer Reports*. Once set up at the back of the counter, they seldom get assembled, unassembled, and cleaned for daily tasks; it's simpler to use a knife and cutting board. And if you want to open a can (although gourmet take-out and frozen/microwavable dishes are more in vogue), a manual can opener remains essentially as efficient as an electric one.

Do more machines mean less time spent on the daily work of living? A mid-1975 study showed that mothers who work outside the home have the fewest leisure hours of any segment of the population. That should come as no surprise to anyone who falls into this category. Although they may own more timesavers, today's women aren't the housekeepers their stay-at-home mothers were. The devices simply help them tend to the basics—feeding and clothing their families—while working full-time jobs.

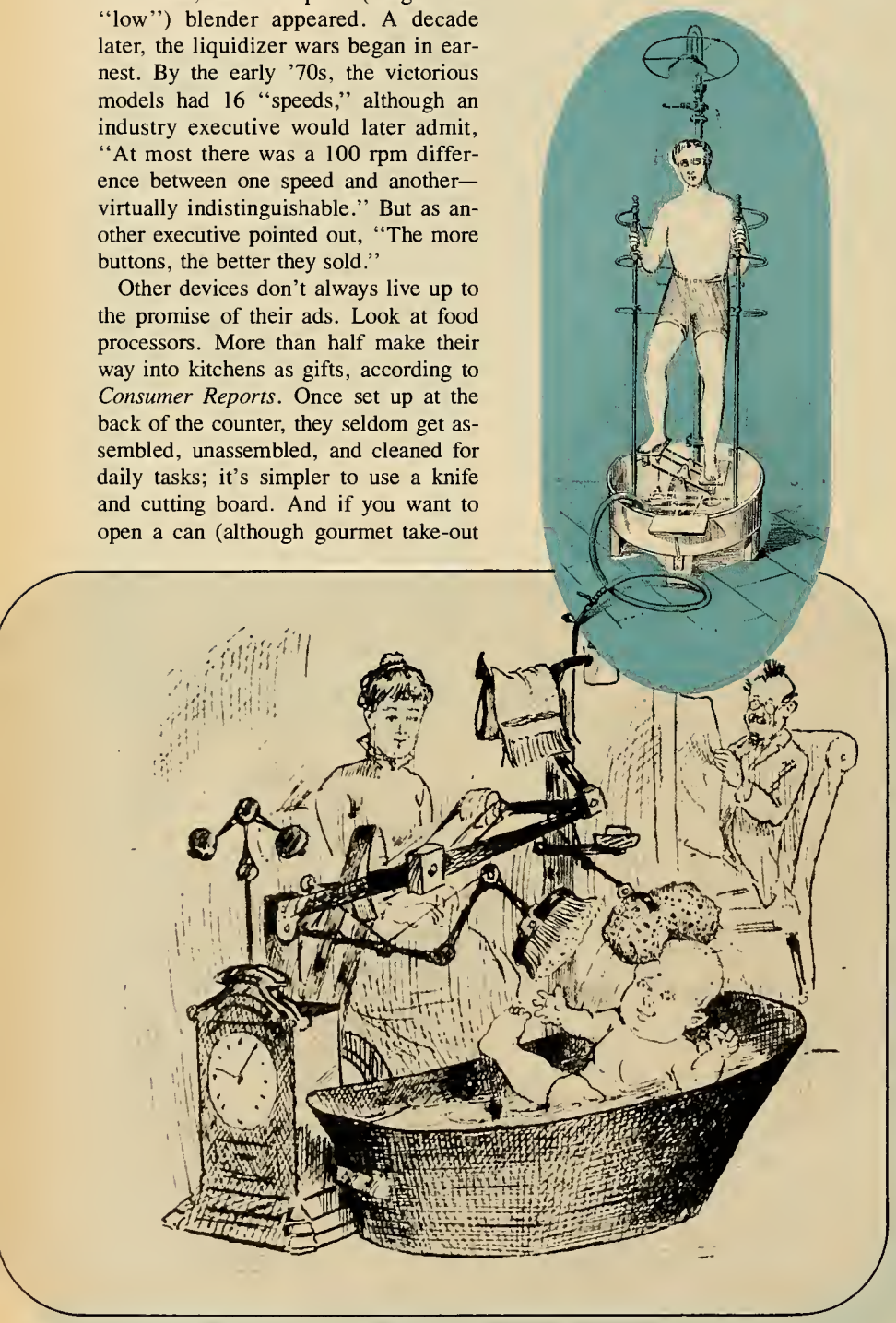
Executives and other professionals who routinely put in 50-plus hours on the job, working schedules that rival those of pre-union sweatshops, also want to get lots of things done—and quickly—at home. To those whose large salaries are a constant reminder that time is money, timesavers become a symbol of status, a declaration that you have more money than time. Witness the class of efficiency-minded devices devoted to having fun, or otherwise doing what presumably you want to do.

Baking bread is a good example. Not too long ago, store-bought bread was viewed as a marvel ("Wonder" Bread was aptly named). Today, baking bread has become a luxury: for many people, the lengthy process is as enjoyable as the end product. But what if you have other things to do? Enter a device which, in the words of a Williams-Sonoma catalog, "not only mixes and kneads bread dough, but also lets it rise for just the right length of time—and then bakes the loaf! All you have to do is measure the ingredients into the non-stick container, put the yeast in the dispenser in the lid, and switch it on. Four hours later, you remove a fragrant loaf. . . ." (Your first homemade loaf will cost you—not including the flour and yeast—approximately $300.)

Exercise is another good example. A machine simulating the aerobic workout of cross-country skiing is geared to people who don't have the time to go "gliding across a snow-covered hillside." Instead, an hour a week is all it takes. Among the promised—if somewhat dubious—benefits: "You'll find you can work longer, with less fatigue."

For certain consumers, time is worth so much that they keep working even when they're at home, aided by a new class of gizmos, many of which wouldn't have been necessary even 20 years ago.

In 1987, when *TIME* magazine sent new subscribers a booklet on time management, it listed five devices that "might make an enormous difference to your productivity." Those five—VCR,



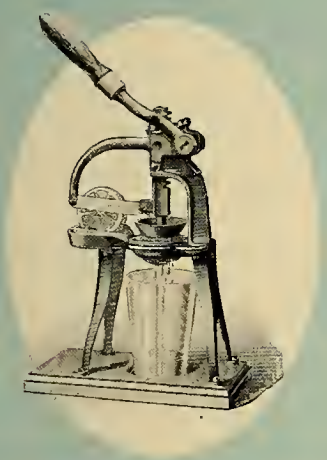
A self-powered pump shower let you exercise while bathing. But necessity may not have been the mother of invention for this baby bather.

Great gizmos: They're chic. They gleam. They even talk and tell time.

Why are some gadgets best-sellers, while others quietly expire long before their patents run out? To judge by those mail-order catalogs geared to buyers with no time for stores, auxiliary features mean as much as efficiency.

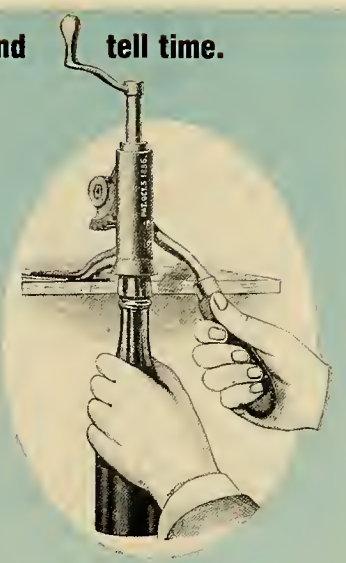
First and foremost, the perfect gadget mustn't get in the way. Appliances from radios to coffee makers to cordless mixers no longer vie for space on a crowded countertop; instead, they hang above it. If this trend of upward mobility continues, the perfect gadget will soon have to be redesigned for use far from the madding crowd, back on the countertop.

The Ajax Lemon-Squeezer



The ideal gadget has several, simultaneous uses. Some contemporary appliances make a certain sybaritic sense: a machine that makes drip coffee, espresso, and steamed milk for cappuccino comes in handy when entertaining; another coffee maker pauses after the first cup so the caffeine addict needn't wait until the whole pot is brewed. Then there's the under-the-cabinet, electric can opener lit by its own electric light—presumably to make it easier to check the contents of the can for incipient botulism.

Whatever else it does, the perfect gadget gives users the time of day—in digital readout. That feature isn't a frill, because the gadget does its task automatically, according to pre-programming or reacting to your instructions from across the room, over the phone, or via another machine. No more pressing an index finger against an electronic touch control. Rather than responding by word-prompt display, the ideal gadget speaks. A new home automation system, for example, delivers its lines in the proper tones of a British butler.



The Hercules Cork-Puller

Last but not least, there's the matter of appearances. Right now, sleek efficiency is in. The more frivolous the gadget, the more serious the look. Finishes are matte black, smooth white, or gleaming chrome. Streamlined curves are evidence that even a motorized, under-the-counter spice rack is a working machine (it even goes in both directions, the ad points out). It is, of course, the D-cell-powered heir to the Industrial Revolution (batteries not included).

personal computer, telephone answering machine, speaker phone, and speed-dialing—are all instruments of communication and information that are now increasingly creeping into the home.

Three of those five tackle telephone-related problems. Answering machines promise the "convenience" of ignoring interruptions from the outside world while satisfying your curiosity about who is calling. Speaker phones keep your hands free for working at other tasks. Speed-dialing takes touch-tone dialing one step further: by pushing a button you dial your most frequently called numbers. It makes the rotary dial a digital dinosaur.

Leisure is seen as something that can always be done faster. The *TIME* booklet bills the VCR as a three-in-one timesaver: It lets you make recordings that skip past the six minutes of commercials in every half-hour of TV, it gives you a storehouse of tapes to play when there's nothing on the tube, and it ends your having to stand in line at movie theaters (not a word, however, about those long lines at video rental stores).

The fifth item? A personal computer, and *TIME* warns it shouldn't just be used for playing games or balancing your checkbook. However, the types of tasks the computer does best—budgeting, data storage, mathematics, graphics, and writing—are usually related to work, not home.

One thing *TIME* didn't mention was a home-automation system. You can already buy low-cost remote controllers to connect to lights and appliances throughout the house. More sophisticated and expensive home-automation systems build up networks of such controllers. Sensors monitor the home, and the system responds, for example, turning on the sprinkler when the lawn's moisture level drops. While these systems are basically add-ons, next year will see the construction of Smart Houses, whose basic wiring allows for pre-programming and voice and remote control of household devices. In a sense, your home becomes a timesaving machine.

Today, "making life easier" can be translated as "making work easier." The two phrases are often, if unconsciously, synonymous. There's an irony involved. Our dedication to saving time and energy is so great that we sometimes find it hard to spend the time and energy we've saved. After all, judging by the high cost of our own labor, what we've accumulated is so valuable it seems sinful to spend it on anything except more work—or more devices to save time and energy.

Mary Ruth Yoe spends her time in Middlebury, Vt., as a writer and editorial consultant. She is a frequent contributer to and former editor of the Alumni Magazine Consortium.

zoo

Zoos, tunes

A DICTIONARY OF CAMPUS SLANG

Like a tide, new words and new meanings come rolling in: dweeb, chill, power snooze. They move from campus to campus, changing subtly. Then, about the time they show up in TV commercials, they're gone, into limbo with "the bee's knees" and "feelin' groovy."

Each generation evolves its own lexicon of "slanguage." It's hard for a student, let alone for a parent or an alumni magazine, to keep up with the way students speak. Yet we've tried, with the kind help of students from Franklin and Marshall College, Johns Hopkins University, Villanova University, Western Maryland College, Western Reserve College, and Worcester Polytechnic Institute. These words are theirs.

As you read, notice how student slang reflects the particular world it comes from. The Eskimos have dozens of words for snow; college students have multiple ways to talk about courses, drinking, partying, sex, doing well or badly, and social status. Some of these words are new while others are familiar, but all listed here are current. They are a way to talk about things students need to talk about. And often what they talk about doesn't reflect activity so much as anxiety.

—EH

air mail

Abuse! (exclamatory): The appropriate response when someone rags or harshes you.

-age (added to the end of any noun for comic effect): tunage (music), crammage (studying for a test), spillage (in a bar, usually beer), theftage (taking a five-finger discount).

airhead (n.): One who is dumb, ditzy, dorky, a bimbo, a dingbat. Most often used of females.

air mail, to get (vb. phrase): To have no mail in the mailbox, only air.

all-nighter, to pull an (vb. phrase): To stay up all night studying or writing a paper. The traditional way, especially for freshmen: "I pulled three all-nighters this week."

awes (adj., rhymes with hoss): Wonderful, terrific. Condensed from awesome, a passé word now used mostly as a joke.

beat (adj.): Bad, boring. Of a party, no one was there. Of a course, extremely hard.

beauteous (adj.): Generically good, used of an event, a scope, a time.

big-time (adj.): Important, impressive, on a grand scale. "I did big-time scoping." Or, "Was it a rough test?" "Big-time." See also: **major,** in a big way.

blizzard, to get a (vb. phrase): At Worcester Polytechnic Institute, to fail, derived from the fact that failing grades are not recorded. Therefore, if you fail all courses, your grade sheet will be blank, white as snow.

blow off (vb., transitive): To cut or bag a class, to reject a person, or to take things easy. "I blew off my eight o'clock" or "She blew me off." Noun and adjective forms also exist: A blow-off course is an easy ace. A blow-off is one who cuts classes all the time and generally makes no effort.

ınd gweeps

Words collected and defined by Elise Hancock
Illustrations by Shaul Tsemach

all-nighter

box (n.): A source of tunes, a radio/tape player. Formerly, boom box.

brain-dead (adj.): Tired, worn-out, beat. Also, brain-damaged, out of it, burned, burned out, wiped, zonked, zoned, zoned out.

cake (n.): A blow-off course, an easy ace. The word has been around a while.

chill (vb.): To calm down, chill out, relax, cool down. Usually said as a command to one who is overwrought: "Chill!" Similarly, "Take a pill!" "Take a chill pill!" "Cool your jets!" "Bring it down a thousand!"

clue (n.): A sense of what's going on, both socially and academically. "Get a clue!"—said to someone who has just done something incredibly stupid.

clueless (adj.): Pathetic, inept, gripless.

cold (adj.): Harsh, nasty, unpleasant, below-the-belt. "That was cold"—what you might say if someone ragging on you gets out of control.

Cool beans! (exclamatory): Good, terrific, always used as a response.

crank (vb.): To study, to do well, to work like a well-oiled machine. "She cranked on that test." Sometimes with "out": "I've got to crank out some major work."

crash and burn (vb.): To do badly.

CUP (n.): A member of the Convention of Ugly People.

diseased (adj.): Socially untouchable, absolutely not fitting in with the crowd.

ditz (n.): A dumb girl. Also, bimbo.

do (vb.): An all-purpose verb; one can "do" almost anything—do books, do dinner, do Vivarin.

do okay (vb.): To do well. It is considered improper to brag outside one's intimate circle. So if some acquaintance asks how you did on a test and you aced it, you say, "I did okay."

do shots (vb.): To toss down hard liquor by the shot glass. As a ritual, to celebrate getting legal.

double-geek (n.): A double-E (electrical engineering) major.

Dr. Staff (proper n.): A Renaissance marvel, obviously the most energetic professor on campus, Staff is listed by the catalog as teaching dozens of courses each year. At Villanova, who you say will teach a course if you don't know.

dump (vb.): To reject, stone, shoot down, or give the boot to someone with whom you've been going out. Stage one of dumping is signaled by the statement, "We're still going out, but we decided we should see other people."

dweeb (n.): A socially unacceptable weirdo, super-clueless, lower than a geek, a person who has *no* redeeming social value.

factor (n.): Used in a turn of phrase that adds emphasis, usually of something disgusting: "The grease factor is definitely there." To have a boot factor of 10 would mean you have an overwhelming need to throw up.

fresh (adj.): Good-looking, used of a woman.

freshman 15: The 15 pounds that almost any first-year student gains. On some campuses, the freshman 10.

fried (adj.): Crushed, totaled, wiped out, obliterated. A common condition after swilling or taking a test: your brain got fried.

friend (n.): Said in a certain tone of voice, replaces "boyfriend" or "girlfriend." One can also sardonically say, "mah *wo*man," "mah bimbo," "mah man," "mah chick." "Main squeeze" and "significant other" enjoyed a brief vogue and are still heard. Actually, there is no satisfactory way to refer to one's significant other. Most usual is to use the person's name. If anyone asks, you say, "We're going out."

geek (n.): A lamo, a person who is socially unacceptable in an earnest, perspiring sort of way. Often an engineering or science major, possessing a watch that beeps. One who overdoes: video geek, EE geek, computer geek. Derives

from carnival slang for a person who bites the head off live chickens. To geek out is to study.

Get a grip! (exclamatory): Get a clue! Pay attention!

girl (n.): Sometimes an acceptable term for a college-age female; sometimes a dire insult. "Woman" is always acceptable.

god/goddess (n.): One who is extremely attractive. With modifiers: an expert on the subject, one who breaks the bell-shaped curve: chem god, sex god, study

Between the lines of the catalog

Air 'n' Sunshine: Arts and Sciences, the liberal arts. Also, Arts 'n' Crafts.

Baby Bio: Biology for those who aren't pre-meds.

Big Chem: A serious chemistry course (as opposed to Baby Chem), normally taken by pre-meds and majors.

Bill on Film: Shakespeare in the Movies (Villanova).

Bowling for Diplomas: A bowling course taken to fulfill the gym requirement (Worcester Polytechnic Institute).

CMPS (pronounced Chomps): Computer Science (Western Reserve College).

DiffEQ: Differential Equations, pronounced Diff-E-Q.

Football Physics: An easy physics course—*very* easy.

Grunge Lab: An engineering lab that teaches materials selection and sand-casting, welding, machine shop, and other activities that make you filthy and grungy (WPI).

Kiddy Chem: A chemistry course long on concepts, short on math. Intended for non-majors.

Kiddy Lit: Children's Literature.

Orgasmic: Organic chemistry. On some campuses, Orgo, O-chem.

Rocks for Jocks: Geology, generally conceded to be the most passable science for persons with, um, no mathematical bent.

Sadistics: Statistics.

Underwater Basket Weaving: Any course with a guaranteed A.

Volts for Dolts: Electrical engineering for dummies.

god. "If the professor doesn't know, the chem god will."

going out (vb. phrase): Definitely a couple, not seeing other people, yet not committed.

golden (adj.): Supreme, classic, used of a glorious, definitive moment: "It was golden. I was hysterical."

goober (n.): A loser, a geek.

Good call! (exclamatory): Good thinking! You're right! Derives from sports.

graffiti party (n.): A party to which everyone wears a white T-shirt and carries a felt-tip pen, the better to inscribe you with.

grip (n.): A hold, a clue, some inkling of what's going on. When a person is out of control, you say, "Get a grip!"

guido (n.): A guy with open collar, lots of chest hair, gold chains glinting, strong grease factor. Often found in a bar.

guy (n.): A male of college age, a young man. In the plural, used of groups and can include females.

gweep (n.): A computer geek, a concave-chested person, almost always male, whose computer is his closest friend. Pronounced with a hard G, the word derives from the sound made when finger hits keyboard. To gweep out is to spend a lot of time at the computer. The word is possibly unique to Worcester Polytechnic Institute.

hating it, hating life (vb. phrase): Said with a certain emphatic drawl (HAAAAT-ing it), expresses the state of mind of one who has 13 weeks of work to learn in one night.

fried

gweep

hang, or (more rarely) **hang out** (vb.): To exist, not doing anything in particular, to be with your friends: "We're just hangin'." Sometimes, to have a hangover. Synonyms: veg or veg out.

Happens! (exclamatory): A response, said with a certain twist in the voice, meaning: Oh well, it's to be expected.

harsh (adj.): Very bad, tough, or hard; worse than beat. A harsh booze would be, for example, tequila.

Hey! (exclamatory): An all-purpose greeting, said without so much as breaking stride. No answer is required. Similarly, "What's up!" "Yo!" "How ya doin'?" "Hey, dude!" The response, if any and also without breaking stride, would be: "Still alive!" "Surviving!" or "Stressing!"

history (n.): Past, gone, out of the picture, often used of people. After breaking up, one might say, "He/she's history."

hit on (vb.): To approach a member of the opposite sex, to attempt a pick-up.

home (n.): Where you live, in a dorm room or apartment.

home-home (n.): Where you come from, a place you visit that parents and siblings may think is your home.

hook or **hook up** (vb.): To connect with something desirable, usually booze or a member of the opposite sex. One might say to the bartender, "Hook me up with some suds." Used as a noun, hook-up implies sex.

hot (adj.): Very good-looking, used of either sex. A hot mug is an attractive face.

in a big way (an all-purpose intensifying phrase): Very much whatever it is: sweet in a big way, spillage in a big way.

intense (adj.): The utmost of whatever-it-isness, whether good or bad. An intense concert blew you away. An intense course is extremely hard.

jam (vb.): To go smoothly, dancingly, jazzily: "I was jamming on that exam." Sometimes used as a synonym for tunes, music.

Just say no (slogan): Offered as mock advice in any situation where people are about to do something they know they should not.

lame (adj.): Not up to expectation, boring, weak, lacking in substance: a lame class, excuse, professor, or party. The variant noun "lamo" would be used only of a person, or as an exclamation.

leech (n.): One who can't hear no, won't leave you alone, attempts to hit on you despite your icy stares.

legal (adj.): To be of drinking age, 21. To "get legal" is to turn 21.

home

library, at the (adv. phrase): Where you say your roommate is when his or her parents call. Similarly, "at church."

license to swill (n.): An ID card that alleges its carrier is over age 21.

lose it (vb.): To be gripless, lose control.

major (adj.): Very important, big-time, on a grand scale: a major party, a major geek. Or, "I have to crank out some major work." Conversely, minor equals unimportant.

mall chick (n.): A certain type of high-school girl most often seen at a shopping center, wearing tight pants, plastic jewelry, artificial-looking hair, eyelashes out to there. Also, mall bunny.

married (adj.): Committed, going together, inseparably coupled, though not literally married. People call such a couple "Mr. and Mrs."

mode, in the —— (adv. phrase): Designates how you're occupied. Examples: in the study mode, in the party mode, in the sleep mode.

my brain hurts: A statement of fact, for whatever reason:. You had a test; you have a hangover. Derived from Monty Python's Professor Gumby.

N.A.C. (exclamatory): Not a Clue! The proper comment when someone is droning on.

nasty (adj.): Ugly, gross, wrong, foul, below-the-belt.

No doubt! (exclamatory): Said with emphasis on both words, a response of enthusiastic agreement. "That's really true!" "I couldn't agree more!" "Totally!"

nuke (vb.): To destroy utterly ("I nuked that test") or to put in the microwave.

orgasmic (adj.): Intense, wonderful, climactic. Often used of concerts or chocolate.

over-rated list, the (n.): The people you don't like head this list. They have won the over-rated tournament.

packed (adj.): Well-built, used of a man.

P.C. (adj.): Politically correct. At one campus, that could mean vegetarian, anti-Contra, feminist, pre-Peace Corps.

P.D.A. (n.): Public Display of Affection. The proper response is, "Get a room!"

photon box (n.): An empty mail box; only light is in it. Similarly, air mail.

pound (vb.) **beer:** To lift 16-ounce arm curls, to drink beer in the chugging mode.

power snooze or **nap** (n.): 15 seconds to 15 minutes of reviving slumber, as in the middle of an all-nighter.

pre-wealth (adj.): Pre-law, pre-med, pre-other lucrative profession.

primal scream (n.): Heartfelt scream emitted during exam week as a form of study break. On some campuses, a group activity for specific times or places, usually midnight. At other schools, may be indulged as each individual feels the need.

psyched (adj.): Worked up, elated, excited, very happy. Often used of readiness for athletic performance.

Quarters (proper n.): A drinking game in which players bounce quarters off the table into a shot glass. Rules vary. Sometimes if you're successful, you may

license to swill

pick someone else to drink up the glass. Other times, if you fail, which is easy, you have to drink.

radical (adj.): Enviable, wonderful, both terrific *and* novel, roughly equivalent to the antique expression "far-out." More common on some campuses: rad.

rag on (transitive vb.): To tease, rip, or cut someone down.

RAM overload (n.): To forget something. From computerese, overload of the Random Access Memory.

rank (adj.): Disgusting, stomach-turning.

real food (n. phrase): Restaurant food, home-home food—any food that is not from a cafeteria.

rents (n., plural): Parents.

run, to make a ——— (vb. phrase): To run an errand: to make a pizza run, beer run, doughnut run.

SAGA (proper n.): A food service corporation that supplies many college cafeterias. At some campuses, said to stand for Soviet Attempt to Gag America.

scary (adj.): Extremely ugly, weird, or otherwise undesirable, to such a degree it is outside nature. Weird people have a high scare bear factor.

scoff (vb.): To bum, or to steal in a benign sort of way, as from the dining hall or from someone who really might not mind, for instance, a banana from one's roommate.

scope (vb.): To check out the scene, looking for someone hot. Once the person is found, he or she might be called a scope. At Worcester Polytechnic Institute, scope is the first of the four S's, which proceed to scam (finding the hot one), scoop (making the hook-up), and scromp (the ensuing activities).

see (vb., transitive): Comparable to the archaic term "to date," meaning to see someone, to go out with someone. Example: "They're seeing each other," said of a couple who've been out more than once, but the relationship is casual. One might be seeing several people.

See ya! (exclamatory): What you say in parting. Also: "Bye," "Peace," "Be good," "Let's blow," "Catch you later," "I'll get back" (black slang), "I'm outta here," "I gotta boogie," "I'm history," or "Later, dude!"

skank (n.): Someone with an unattractive personality. Also, dirtball, scumbag, slime, sleeze, scab, or dink.

slam (vb.): Brutally to reject, to shoot down, to spike or ace another human being.

slime (n.): One who is lowlife; a mattress-back, a slimeball, a sleazebag, a trollop, a slam piece, a gross and cheesy person. A very young piece of slime might be called a sleaze puppy.

So I shot 'im! (exclamatory): A phrase designed to draw attention, used when you're telling a long story and no one is listening. Similarly, "So *he* was dead."

stick it in the queue (exclamatory): Add something to a pile, as putting your coat on a mound of coats; from computerese.

stressing (adj.): To be under stress, schizzing, losing it; a common condition during exams.

stud muffin (n.): A very good-looking guy. Also, stud cake. Adj.: studly. As a joke, a good-looking woman might be called a stud-ette.

super-senior (n.): Someone who failed to graduate and is still hanging around, pathetically taking a few last courses. Also, to be on the five-year plan, the six-year plan, the seven-year plan.

sweet (adj.): Sexually attractive, hot, fresh. Used only of females.

swill (vb.): To consume, to drink an alcoholic beverage. Also to pound, slam, chug, hammer, tip back, catch a load, catch a buzz, or hook up with a buzz. A swilldog is a lush.

tacky tourist party (n.): A party at which one wears a lame shirt and carries a huge camera, guidebooks, etc.

team Xerox (vb.): To copy a set of homework problems, usually from the year before, for a group.

ticket meal (n.): In the dining hall, a meal that requires a special ticket because it is supposed to be especially good, but which turns out to be only mystery meat, or maybe Pucks 'n' Crayfish (turf 'n' surf).

tight with (adj.): Intimate with, close to, either to a friend or to a lover. On some campuses, a very connected couple is "tight at the hip" or "joined at the hip."

toasted (adj.): Buzzed, somewhat drunk.

tool (vb.): To do well, to crank.

tool (n.): An insentient thing masquerading in human form, a jerk, a fool.

total (adj.): Very, really, utterly; an all-purpose intensifier.

Totally! (exclamatory): "I agree!" "Even more so than what you said!" Example: "Wow, that was a really good tune!" "Totally!"

trashed (adj.): Extremely drunk. Also, loaded, wasted, hammered, wrecked, bombed, slammed, outta hand, gone.

tunes (n., pl.): Music of any sort, or the source of music. As in, "Put some tunes on" (put on a record) or "Grab some tunes" (bring the radio). The tune master controls the tunes.

twit (n.): An airhead of either sex, a dork.

veg (vb.): To do nothing, think nothing, just hang; vegetate. Veg out is used less frequently.

Vivarin (proper n.): Caffeine pills, now preferred to the classic No-Doz.

wanked out (adj.): Exhausted, very tired.

wastoid (n.): A drunken burnout.

way (adv.): Very, as in way funny, way harsh. Similarly (said with emphasis), *too* cool, *too* funny.

whipped (adj.): Of a guy, "married," never seen without his woman. Implication is that she nags him and runs his life.

wired (adj.): On your fifth wind—excited, nervous, overwrought, stretched, and exultant. Too much Vivarin would do it.

wonk (n.): A computer geek.

Yo! (exclamatory): A greeting.

za (n.): Pizza.

zel (n.): Pretzels.

zog (vb.): To drink beer in the chugging mode.

zoning (vb., present participle): Same as antique expression "spaced out": to be a human vegetable, to hang, to major in couch potato.

zoo (n.): Registration or any other confused, crowded situation.

Elise Hancock met with some 80 students in gathering "slanguage" for this article. Former editor of the Johns Hopkins Magazine, *she is now university editor at Hopkins.*

74 to 1

With the Odds Against Them, WPI's First Women Undergraduates Paved the Way for Those Who Followed

Sixteen years ago, a lone woman, Lesley Small Zorabedian, walked across the stage in Harrington Auditorium and into WPI history, becoming the first woman to receive an undergraduate degree from the college. The following year, a small group of women made that same walk, earning their B.S. degrees with the rest of the Class of 1973. The frustrations and successes of those pioneering women changed WPI forever.

By EVELYN HERWITZ

There were no big anti-war rallies, no major civil rights demonstrations, no sit-ins or classroom take-overs. But at WPI in 1968, a social revolution of a different sort was just beginning—a change in century-old traditions that would alter the face of campus life.

It was a time when WPI's students were required to attend R.O.T.C. classes Saturday mornings, when weekend parietal hours had just been established, when the campus was headed by a three-star general. And it was a time for evaluating the way things had been done since the Institute's founding in 1865.

The curriculum and grading systems weren't the only topics scrutinized during that introspective period; there was the more sensitive question of who should attend WPI in the first place.

For more than 100 years, undergraduate enrollment had been limited to men, a situation that suited some faculty and students just fine. Two women had earned master's degrees at WPI—the first in 1957—and two more would earn graduate degrees before the 1960s were over. But the voices of those who felt women also had a right to an undergraduate education in the engineering and science disciplines were becoming more insistent. In 1968, they prevailed.

At a Board of Trustees meeting on February 10 of that year, the decision was made to admit women undergraduates to WPI. The news hit campus on Valentine's Day in the form of a brief page-one article in *The Tech News*. Headlined "Board Approves Plan for Coeds," the article quoted President Harry Storke:

" 'We have been receiving an increasing number of serious inquiries from scholastically qualified young women who could benefit from the quality of education Worcester Tech provides . . . With a much higher percentage of women preparing for courses in engineering or science, it was inevitable that this college would open its doors to the ladies . . .

" 'Worcester Tech's founder, John Boynton, recognized that the school would have women students someday when the trustees felt the time was appropriate. That time is now.' "

While President Storke put the best public face on the decision, the Board's approval had not been achieved without some serious debate and internal protest. Dean of Undergraduate Studies William Grogan recalls some of the arguments he heard as a young, active faculty member who in the late 1960s chaired the curriculum committee.

"It had been talked about for a long time," he says. "Some senior faculty members felt that engineering was not an appropriate field for women—that it was OK for women to study math or physics, but that engineering was a man's world.

"But most of the discussion centered on costs and how to handle the change. There were endless discussions about housing and use of the gym, locker rooms and pool."

Though not privy to the executive board discussions that led to the final decision to accept women, Grogan attributes the move to two major factors:

"First, it was a time for new and liberal thinking. We were really questioning everything we were doing. It was a natural extension of that process to ques-

tion the attitudes of the college toward women students.

"There was also thought about long-range economics—engineering school applications were not strong anywhere nationally, part of a general reaction against technology. Those trends certainly encouraged whatever other thinking supported opening the college to women."

The decision to admit undergraduate women came too late in the academic year to make possible an aggressive recruitment effort for the fall. As a result, only two women entered WPI as freshmen in September: Lesley Small, a graduate of David Prouty High School in Spencer, Mass., and Jayne Rossetti, of Hopedale (Mass.) Junior/Senior High School. Both were class valedictorians.

Their names, faces and accomplishments were known to WPI men well before their arrival. A picture of the two women appeared on the front page of the May 8 edition of *The Tech News*. The previous week, the student paper had introduced their names and achievements, adding, "The girls stated that they are a little scared and nervous about entering a school which was previously all-male. But Miss Small did state that she has been in all-male classes in high school so that it's really nothing new."

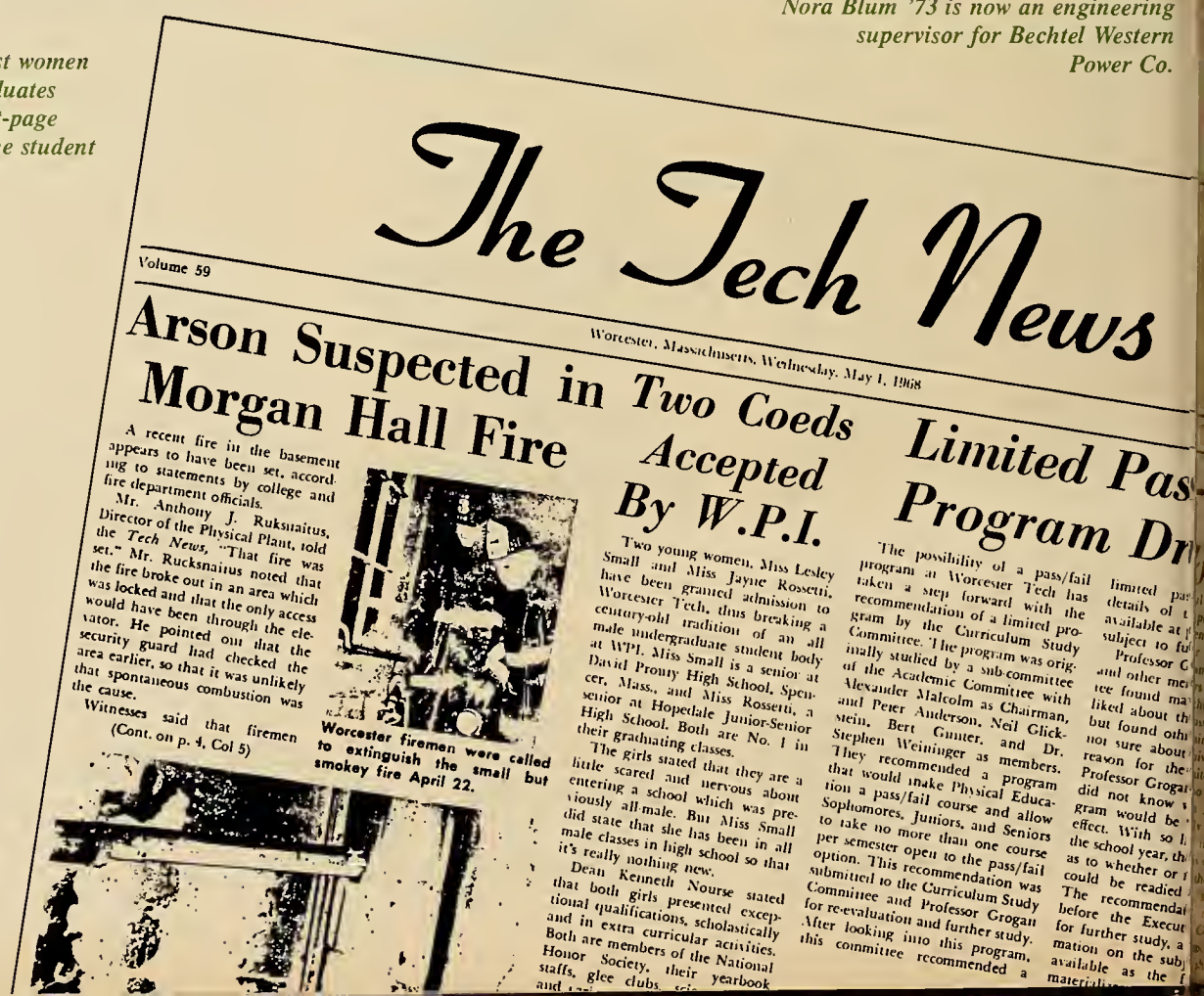
But the reality of being one of only two women undergrads turned out to be a whole new experience for Lesley "Lee" Small Zorabedian ('72 MA), who now has four children and lives in Reading, Mass.

Since there were no residence halls

Courtesy of Bechtel Western Power Co.

Nora Blum '73 is now an engineering supervisor for Bechtel Western Power Co.

WPI's first women undergraduates were front-page news in the student paper.



The Tech News

Volume 59

Worcester, Massachusetts, Wednesday, May 1, 1968

Arson Suspected in Morgan Hall Fire

A recent fire in the basement appears to have been set, according to statements by college and fire department officials.

Mr. Anthony J. Ruksnaitus, Director of the Physical Plant, told the *Tech News*, "That fire was set." Mr. Rucksnaitus noted that the fire broke out in an area which was locked and that the only access would have been through the elevator. He pointed out that the security guard had checked the area earlier, so that it was unlikely that spontaneous combustion was the cause.

Witnesses said that firemen

(Cont. on p. 4, Col 5)

Worcester firemen were called to extinguish the small but smokey fire April 22.

Two Coeds Accepted By W.P.I.

Two young women, Miss Lesley Small and Miss Jayne Rossetti, have been granted admission to Worcester Tech, thus breaking a century-old tradition of an all male undergraduate student body at WPI. Miss Small is a senior at David Prouty High School, Spencer, Mass., and Miss Rossetti, a senior at Hopedale Junior-Senior High School. Both are No. 1 in their grathating classes.

The girls stated that they are a little scared and nervous about entering a school which was previously all-male. But Miss Small did state that she has been in all male classes in high school so that it's really nothing new.

Dean Kenneth Nourse stated that both girls presented exceptional qualifications, scholastically and in extra curricular activities. Both are members of the National Honor Society, their yearbook staffs, glee clubs, sci-

and

Limited Pas Program Dr

The possibility of a pass/fail program at Worcester Tech has taken a step forward with the recommendation of a limited program by the Curriculum Study Committee. The program was originally studied by a sub-committee of the Academic Committee with Alexander Malcolm as Chairman, and Peter Anderson, Neil Glickstein, Bert Gunter, and Dr. Stephen Weininger as members. They recommended a program that would make Physical Education a pass/fail course and allow Sophomores, Juniors, and Seniors to take no more than one course per semester open to the pass/fail option. This recommendation was submitted to the Curriculum Study Committee and Professor Grogan for re-evaluation and further study. After looking into this program, this committee recommended a

limited pas
details of t
available at t
subject to fu
Professor G
and other mem
tee found ma
liked about th
but found othe
not sure about
reason for the
Professor Grogan
did not know
gram would be
effect. With so l
the school year, th
as to whether or
could be readied
The recommendat
before the Execut
for further study, a
mation on the sub
available as the
materials

"I didn't want special treatment. I just wanted to be treated as one of the students."

equipped to handle the two newcomers, both women lived off-campus and commuted their freshman year. "I felt very lonely," says Zorabedian of that first year. "I went to class and came home. I really didn't have a place to go. The library was my home base."

"On a day-to-day basis, I was in sections of 20 or 25 men, and that wasn't so bad. But I was shy, and I didn't want special treatment. I just wanted to be treated as one of the students."

That shyness kept Zorabedian from venturing onto the quadrangle by the men's dorms well into her second semester. "I didn't want to be seen."

By her sophomore year, however, she had begun to join in campus activities. At a dorm committee meeting the previous spring concerning the needs of incoming freshman women, she met classmate Jack Zorabedian, whom she later married.

And then there were the 24 women who came to WPI in the fall of 1969. With their arrival, the ratio of men to women teetered at a lopsided 74 to 1. But for Zorabedian, who was now able to live on-campus, even small numbers were a welcome change: "It sure was nice to have female company," she says.

Housing accommodations consisted of half the first floor in Sanford-Riley Hall. Triples and a few doubles, plus a resident advisor's suite, were set off from the rest of the dorm by a pair of fire doors at either end of the hallway.

With the women came many changes to the formerly all-male environment: urinals were changed into planters, shower curtains added privacy to gang showers, full-length mirrors and curtains graced dorm walls and windows.

And there were changes in residence hall rules as well. For example, restricted visiting hours for women in male dorms soon went by the boards.

But the most profound changes—those that affected the basic social structure of the campus and classroom—took longer and were much more difficult to achieve.

Janet Woodcock

One of just two women accepted in 1968, Lesley Small Zorabedian '72 felt conspicuous on campus; the situation improved the following fall when WPI admitted 24 more women.

"They finally discovered we were not walking computers, but real people."

Janet Woodcock

Mary Zoeller Murray '73 recently joined Phoenix Technologies, Ltd., as director of marketing programs.

"That first term was crazy," remembers Janet Merrill Mambrino ('73 MA), who now runs a computer consulting firm with her husband in Old Saybrook, Conn. "I remember people taking pictures of us as we walked across campus because we were such an oddity," she says.

"The guys felt we must be eggheads—slide rule on the belt and all that. Women weren't supposed to be into science, so they figured we must have been either very brilliant or very strange."

"The majority of boys did not like us girls—we were invading their turf," agrees classmate Deborah (LaPlante) Goodwin ('73 MA), a math tutor in Greenville, S.C. "We would go into the cafeteria en masse and no one would sit by us. Then we tried to sit individually, and still no one would sit by us."

Those memories are shared by mathematics Professor John van Alstyne, then dean of academic advising and still friend to many of WPI's first women graduates. "When the women first came in, they had a terrible time," says van Alstyne. "The men resented them based on fear. The women were very bright, and they had to be highly motivated to withstand the guff they took.

"They were more conscientious regarding assignments, so the men had to work harder to keep up, and they didn't like to look stupid in front of the women.

"In addition, most of the male students came from families where women stayed home while the men earned a living. These women were stepping out of traditional cultural roles, and the men didn't understand. The women were on center stage from day one."

That uninvited notoriety proved to be a personal challenge for each of the new freshmen, complicating the normal stresses of a first year at college.

"You got a lot of attention—sometimes it was good and sometimes negative," recalls Nora A. Blum ('73 CE), now an engineering supervisor with Bechtel Western Power Co. in Norwalk,

Calif. "It could make you feel important or be overbearing. Sometimes you had the feeling that everyone was watching; it made you wonder if you were some kind of freak."

In addition to contending with male students' fears and prejudices, the women also had to confront the occasional male professor who would make life that much more difficult.

"I remember walking into my chemistry class the first day," says Janet Merrill Mambrino. "The teacher said he didn't feel women belonged in an engineering school, and if I wanted more than an F, I'd have to really prove myself."

Fortunately, such instances were the exception rather than the rule. And by mid-year, tensions with the male students were easing as well.

"The turning point for me came at the end of our first semester," says Mary Zoeller Murray ('73 CH), who recently moved back East from California to take a position in technical marketing with Phoenix Technologies, Ltd., in Norwood, Mass.

"A group of gentlemen at the other end of the hall gave a Christmas party for us. It was a very nice gesture. I felt like we had comrades—friends."

Gradually, as, in Deborah Goodwin's words, "they finally discovered we were not walking computers, but real people," the WPI men began asking their new acquaintances out on dates. That, too, was a major departure from campus tradition, which favored women from Becker Junior College and local nursing schools.

But dating also singled out the women in yet another way. "By their sophomore year, the women were being asked out by seniors," says van Alstyne. "But whenever a senior would ask one of the women for a date, everyone else on campus would know about it, because there were so few of them. So it was like the men had staked out a claim, and others would be afraid to ask them out."

Nonetheless, some couples inevitably formed, and several of the women, including Lee Small, Deborah LaPlante and Elizabeth C. Poulin, eventually married WPI men—John Zorabedian Jr. ('72 CM), Stephen Goodwin ('73 EE) and Frank Steiner ('71 ME) respectively.

As more women were admitted to the college, the novelty of coeducation began to wear off, and campus life settled into new social patterns. Those in the Class of '73 continued to distinguish themselves academically, and a few started to venture away from the hard sciences they had favored since high school and into the male bastion of engineering disciplines.

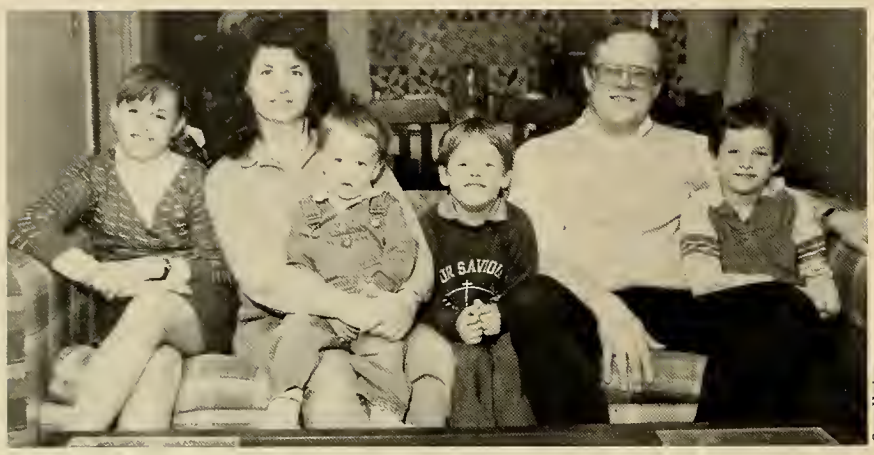
They also became involved in extracurricular activities. In the absence of sororities, some, like Diane Gramer and Janet Merrill, pledged as fraternity "brothers" to Alpha Epsilon Pi. Lee Small became the first woman president of Tau Beta Pi, the engineering honor

Christina Herzegh

Elaine Kowalewski Tepper (MS '71) was WPI's first woman resident advisor.

Courtesy of Hamilton Standard

Dean Gramer Drew '73 is now a senior design engineer for Hamilton Standard in Suffield, Ct.



Scott Herke

Deborah and Stephen Goodwin '73 with their children in Greenville. S.C.

society, while Nora Blum became the first woman to edit the *Tech News*. Others helped to form some women's athletic teams in crew, fencing and basketball, and many became cheerleaders.

"In picking the initial students, [Dean of Admissions] Ken Nourse tried to select strong candidates, because he knew they would face a lot of problems," says van Alstyne. "He picked women who had a good chance of succeeding, and most of them lived up to his expectations."

For many of the women, van Alstyne was an important key to their success, as well as newly appointed Assistant Dean of Students Bernie Brown. " 'Van A' was like a father to us all," says Beth Poulin ('73 MA, '78 M.S.ME), now a research engineer with Foster-Miller Inc. in Waltham, Mass. "He'd often call us into his office—he kind of knew when things were going wrong. And Dean Brown was very good to us."

Now vice president for student affairs, Brown gives special credit to one other individual who helped ease the coeds' transition—WPI's first woman resident advisor, Elaine S. Kowalewski. A first-year graduate student in mathematics, Kowalewski was a "main resource" for Brown at a time when no counseling center existed and there were no other professional women on campus.

Nicknamed "Ma Riley" after their home in Sanford-Riley Hall, Elaine Kowalewski Tepper ('71 M.S.MA), now a programmer analyst with AT&T in White Plains, N.Y., has warm memories of her years as resident advisor: "I tried to keep my door open—I was really very fond of the women. Even though I was four years older, we all had a common bond."

That kind of support, a lot of hard work and a willingness to take risks, enabled most of the group to finish their four years at WPI among the top students of their class. Twenty of the original 24 completed their studies and received degrees, following the example of Lee Small, who had become the first woman undergraduate to graduate from WPI the previous year. (Jayne Rossetti dropped out for personal reasons midway through her WPI career.)

And then the real challenge began.

"In college everybody treated me as an equal," says Diane Gramer Drew ('73 HTE), a senior design engineer at Hamilton Standard in Suffield, Conn. "In the working world, I found things much more different—more prejudiced.

"I'm still dealing with it. It's hard being a woman engineer. All the managers are men, and most of the engineers are men. A woman has to work harder to prove she can do something."

Her experiences were shared by Nora Blum in her first engineering position with a Boston firm: "In a new situation, people who didn't know you would assume you were Joe's secretary. Sometimes it was almost funny and sometimes you could get really upset.

"My reaction was to keep my anger inside. I'd pound my desk in private and think, damn it, I'm going to show them. Then I'd do a very competent job. With experience I became more confident and others became more accepting."

For many of the women, their early years at WPI helped them to bolster their self-esteem as they met challenges later in life. "If there's one thing I learned from that time, it's that there's nothing you can't do if you really want it," says Zorabedian. "It's a belief I hope to instill in my own children."

It's also a belief that a number of the alumnae have shared with WPI's current women undergraduates during campus visits. The group they address today—accounting for 17 percent of the student body—enjoys a number of benefits they lived without: coed athletic facilities, three sororities, more women staff and faculty members and the acceptance that comes with nearly two decades of experience with women students.

Administrators like Bill Grogan look forward to the day when women will account for at least a fourth of undergraduate enrollments. And Bernie Brown thinks that, despite how far the college has come with coeducation, there is still room for improvement.

But getting this far, he adds, could never have been accomplished without the help of those first two dozen who sensitized WPI to women's issues and needs.

"It was such a special group," says Brown. "They fought the early battles for those who came after."

Evelyn Herwitz, a free-lance writer living in Worcester, is a frequent contributor to the Journal.

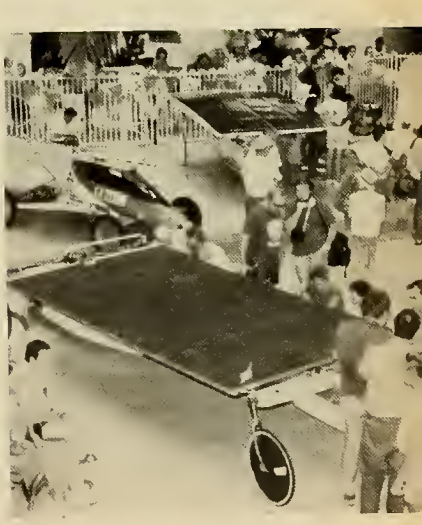
A Personal Adventure

Across the Australian Outback with the World's First Transcontinental Solar Car Race

By Edward N. Clarke

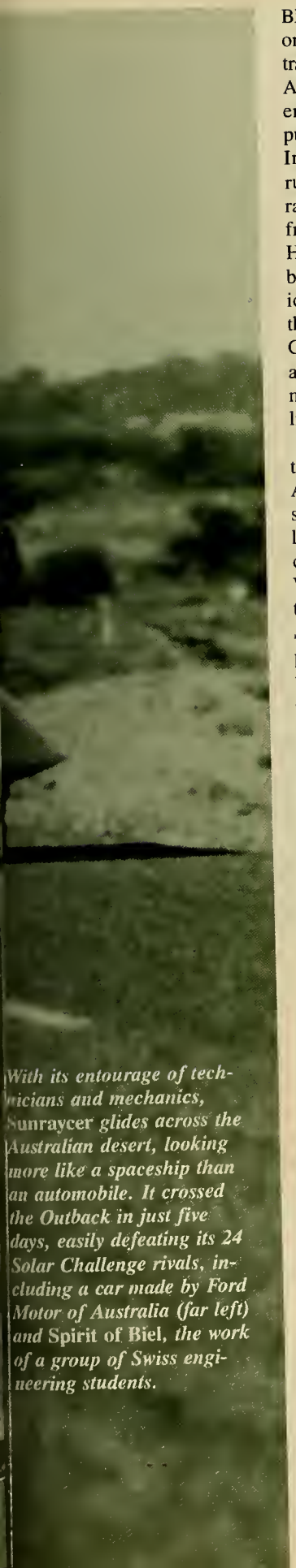
Photos by Ed Clarke and General Motors

Left: GM's Sunraycer *at the finish line with the World Solar Challenge cup. Below: the challengers were on display in Darwin before the race.*



I flew to Sydney, Australia, in late October 1987 and thence to Brisbane, where I boarded a bus for the 2,500 mile, 2½-day trip northwest to Darwin. By the time my travels in this continent would end, I would cover 6,000 miles of lovely, wild land; see strange, exotic and dangerous animals; sleep in the open under the endless Australian sky and slog through four inches of rain in a desert outpost that had not seen a storm in 13 years—all to get a chance to witness the World Solar Challenge, the first ever transcontinental solar car race. What an odyssey it was!

SPIRIT
17



With its entourage of technicians and mechanics, Sunraycer glides across the Australian desert, looking more like a spaceship than an automobile. It crossed the Outback in just five days, easily defeating its 24 Solar Challenge rivals, including a car made by Ford Motor of Australia (far left) and Spirit of Biel, *the work of a group of Swiss engineering students.*

BEGINNING IN DARWIN, on the northern coast of Australia, the course crossed the Australian Outback before ending in Adelaide, 2,000 punishing miles south on the Indian Ocean. Had it been run in North America, the race would have stretched from Calgary, Alberta, to Houston, and would still have been a human and technological milestone. But crossing the Outback made the Solar Challenge both grueling and, at times, dangerous—and the most exciting adventure of my life.

In all, 24 vehicles started the race on a warm spring (in Australia) day. When the last stragglers crossed the finish line some 30 days later, 14 cars had reached Adelaide. When all was said and done, the General Motors (GM) *Sunraycer*, powered completely by solar cells, or photovoltaics, and batteries charged only by the sun had raced the distance in a little over five days, averaging 42 miles per hour and defeating the second-place Ford entry by a good two days.

Since returning to the States, it has been hard to contain my enthusiasm for what I was a part of. People frequently ask me how I became involved. It was in early 1987 that I learned of the Challenge race and its vision of demonstrating that automobiles could run continuously with no source of energy other than the sun. This was history in the making in my field of technology, and I wanted to be a part of it.

GM announced its plans to participate in the Solar Challenge in the spring of 1987, with just seven months left until race time (most of the other competitors had already been at work on their entries for more than a year). I contacted Robert Stempel '55, who had just become president of GM, and told him of my interest. Bob put me in touch with the manager of GM's solar car program and its public relations director. I was fortunate enough to be invited to the unveiling of the *Sunraycer* in Detroit that September, an event that made news nationwide.

GM invited me to travel across the Outback with the safari that would accompany *Sunraycer*. But as exciting as that offer was, I soon found myself facing the kind of dilemma we all dream of, for the opportunity had arisen for me to travel in the safari of race organizer and modern adventurer Hans Tholstrup. Here was a chance to follow not one but a number of the 24 national teams throughout the race.

Accompanying Tholstrup was a chance I couldn't pass up, though I am grateful to GM for enabling me to become involved with the Solar Challenge in the first place. I had come to know a number of the GM team members, whom I now count as friends, but I wanted an even broader experience.

AUSTRALIA IS A VAST NATION the size of the continental United States. Most of the country's 17 million people, however, live in the southeast and on the east coast. This is where the British dumped convicts in the late 18th and early 19th centuries, and many Aussies are still conscious of their felonious forebears.

Most of the continent is tropical or arid, with the hottest region lying in the center. It was through this hot, dry land that the race passed, rolling along the famed Stuart Highway. Giant termite mounds—some up to 15 feet high—ubiquitous insects, kangaroos, dingoes, goanna lizards and large poisonous spiders were the order of the day—and night.

The Solar Challenge passed through two Australian states—starting in Darwin in the tropical Northern Territory, passing through the desert-like Outback of South Australia and ending in Adelaide, near beautiful rolling hills of wheat fields, vineyards and sheep farms.

As the weather turned colder back home, summer was approaching in Australia. In fact, temperatures may have reached 114 degrees while we were in Darwin, a city of about equal latitude as Lima, Peru. For once, I'd been able to extend the Indian Summer we so cherish in New England.

The 24 solar racers that arrived for the start of the race originated in Denmark, Japan, Pakistan, Switzerland, West Germany and Australia, in addition to the GM *Sunraycer* from the U.S. Three Australian high schools competed, as well as colleges and universities.

The best college solar cars came from the engineering college in Biel, Switzerland, and the Darwin and Chisholm institutes of technology, both in Australia. *Spirit of Biel*, the Swiss car, which had backing from Mercedes Benz, finished third. The Australian university entries came in fifth and sixth, respectively. Farther down in the pack were cars built by students at MIT and Crowder College in Missouri.

Time trials in Darwin on the day before the start of the race determined the starting positions, much as they do at the Indianapolis 500. *Sunraycer* won the pole position with a speed of 70 miles per hour. The Hawaiian *Mana La* ("power of the sun") got the other front-row slot.

Each entry was also required to demonstrate stability against the air turbulence created by passing road trains—truck tractors pulling three large trailers in tandem. Up to 130 feet long, with 72 wheels, these monsters travel

100 miles per hour carrying 120-ton payloads! In addition to *Sunraycer*, *Mana La*, the Ford Motor of Australia car and the Swiss car performed well in these trials.

On November 1, the Challenge got under way—fortunately under bright blue skies and intense sunshine. By the end of the first day's racing, *Sunraycer* had opened up a 68-mile lead on its closest competitor, the Swiss team, and was 73 miles ahead of the Ford. *Mana La*, meanwhile, had made some strategic errors, and before racing ended at 5 p.m., its batteries died, leaving it 87 miles behind GM.

Day 2 dawned cloudy—a threatening surprise for most of the cars, for race rules prohibited charging batteries with any source other than the sun. By that evening, *Sunraycer*'s lead was up to 150 miles. And, by the end of the third day, *Mana La* had dropped out for good, though it was not the first to quit.

By the time *Sunraycer* rolled across the finish line, it had opened up a gap of 600 miles between itself and the Australian Ford car, the second-place finisher, and more than 1,000 miles between itself and the last of the 14 entries that completed the Challenge within the 10-day official limit of the race (two cars would take a month to get to Adelaide).

After the GM and Ford entries came the *Spirit of Biel*. The Swiss car would probably have done better had it not collided in central Australia's Alice Springs with a conventional automobile that had entered an intersection at precisely the wrong time. Ironically, it was the driver of the Swiss car who wound up getting a ticket.

In a display of automotive wizardry, the Swiss had their car repaired and back on the road in less than six hours. But, by then, they had lost second place to Ford for good.

I had the privilege of spending two fascinating nights with the Swiss team—the night after the collision and the night before their final day of racing. It was on this second night that they made the emotional decision to reach the finish line before the end of the next day, even if it meant racing beyond 5 p.m. and thus accumulating penalty points for being on the road at that hour.

Somewhat to our surprise, the three Japanese entries performed relatively poorly. In fact, all three were still in the Outback as I was leaving Australia. But the Japanese had ample opportunity to study *Sunraycer* and, perhaps, will make use of what they saw.

DURING THE RACE, solar car drivers slept in tents, vans, trucks, station wagons—wherever they could find a restful spot—when they finished their turns at the wheel. While in the tropical part of the Outback, I slept on the desert in a sleeping bag, making certain that my exposed little "bedroom" was free of the 2-inch poisonous spiders that were everywhere—at least they weren't around when I first lay down to sleep. I guess I assumed that kangaroos were too timid to come near and that goanna lizards would simply stay away.

For the physical exercise that is an invaluable part of my daily ritual, each morning before the cars got under way at 8 a.m. I ran three or four miles in the Outback. I suspect this has to be some sort of record, for it even drew the attention of television crews covering the Solar Challenge.

Of the six GM drivers, three were from the United States, including Molly Brennan, an engineer from the New Concepts Division of GM. A graduate of Michigan State University, where she studied computer engineering and the humanities, she was also a Rhodes Scholar. During the race, Molly drove three segments, including one over a rough section of road under construction and another on a stretch newly resurfaced with asphalt and pebbles. Both surfaces caused tire failures, but the crack GM race team had the tires replaced in under two minutes. These were the only mechanical problems *Sunraycer* suffered in the whole length of the Solar Challenge, a testament to the quality of the design and engineering that went into it.

WPI's Stempel Launches a Bit of Engineering History

While the General Motors *Sunraycer* is the product of several GM divisions and the experience and talent of dozens of engineers and technicians, it began with the vision of one man and the bold decision of another. It was Howard G. Wilson, vice president of the General Motors Program of the Hughes Aircraft Company, who first suggested that GM enter the Solar Challenge.

Wilson's suggestion fell on the receptive ears of Robert C. Stempel '55, who assumed the presidency of GM one day before delivering the 1987 WPI Commencement Address.

It was Stempel who made the key decision to produce *Sunraycer*—to commit the resources of GM to a crash program to design not just a solar-powered car, but a new concept in automotive technology. The result is as beautiful as it is brilliant.

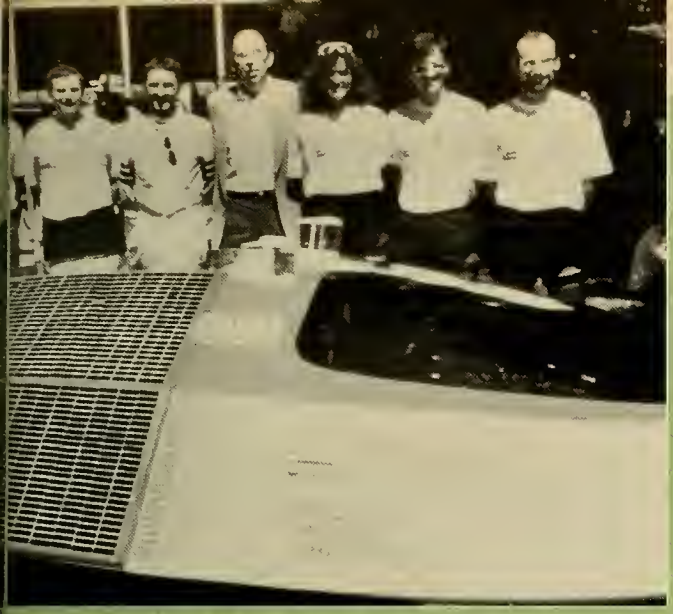
Packed into the *Sunraycer* is some of the world's most advanced technology: lightweight materials, low-friction moving parts, high-efficiency solar cells, advanced motor and power electronics, advanced aerodynamics, experimental batteries, and regenerative braking, a technique that enables the drive motor to generate energy and feed it back to the batteries when the driver takes his or her foot off the accelerator.

The car has the planar dimensions of a family station wagon, but weighs only 360 pounds—just under 550 pounds with driver. Its chassis weighs in at a scant 15 pounds, and the entire shell is less than 100 pounds! The body is made of a sandwich of Kevlar and Nomex. The car's bicycle-type tires are 17 inches high and made of Kevlar as well. Inside, the driver sits neatly suspended in a comfortable sling seat.

Sunraycer's drive motor is one of the most efficient power

Driver Molly Brennan and a GM crew member

MY OVERRIDING IMPRESSION of the Australian Outback was of a vast, desolate land with precious few people, stretching from tropical in the north to barren in the south. Traveling down the Stuart Highway, I was in awe as I realized that this wilderness extended uninterrupted to the east or west for more



bert Stempel '55 (center) with the drivers and crew of
nraycer. Stempel's decision launched the **Sunraycer** *project.*

plants ever produced. Dubbed "Magnequench" to describe its powerful permanent magnets, the motor produces a steady two horsepower with a capacity for 10 horsepower bursts. It weighs less than 10 pounds.

The car's photovoltaic array is made of 7,200 gallium arsenide solar cells, made by GM's subsidiary, Hughes Aircraft Company, and other manufacturers. The solar cells used by the other challengers were made of less expensive, but also less efficient, silicon. GM also used a different approach to mounting the cells, gluing them directly onto the streamlined, teardrop-shaped body of the car to reduce drag. Most competitors used a bulky overhead panel, tending to make these cars look as if they were hauling their arrays rather than integrating them into the car's aerodynamics.

The peak output from *Sunraycer*'s eight square meters of solar cells is 1,500 watts. That's the power consumed by an ordinary countertop toaster. But 1,500 watts can drive *Sunraycer* at 45 miles per hour—trickle charging the batteries at the same time—and up to 70 miles per hour if augmented by the solar-charged batteries. In photovoltaics, the name of the game is efficiency. *Sunraycer*'s silver-zinc batteries, also produced by Hughes Aircraft, are one-fifth the weight of lead-acid batteries used in most cars.

AeroVironment, Inc., of Monrovia, Calif., created the sleek, low-drag design of *Sunraycer*. The company has had plenty of experience in the design of lightweight vehicles. Its founder, Paul MacCready, designed the *Solar Challenger*, the first aircraft to cross the English Channel powered entirely by the sun.

MacCready was awarded an honorary doctor of engineering degree from WPI in 1980. His degree citation stated, in part, that his aerodynamic designs "have lifted our spirits, fired our imaginations and expanded our horizons. He has given us all a new sense of the possibilities of our bodies and of our technology."

Though GM had a clear advantage with its technology, the company left little to chance. Racing experts were brought in to carefully study the Stuart Highway and devise tactics for the race. One of those tactics, which had the driver use extra power for the first 15 minutes of the competition, helped give *Sunraycer* a lead it never relinquished.

During the race, technicians in an air-conditioned trailer followed the solar car and monitored its energy consumption and production, the weather and road conditions, wind speed and other key factors. They used a computer to help the drivers get the maximum performance from the motor and make the best use of the battery charge.

Despite the success of *Sunraycer*, GM says it has no plans to mass-market solar-powered cars. I had asked that question openly and publicly—with GM chairman Roger Smith present—back in Detroit after the unveiling of *Sunraycer*. Later that day, a number of GM design engineers thanked me for raising the question. Apparently, some at the nation's largest auto maker would like to produce a solar-powered commuter car. —EC

than a thousand miles.

On one of our safari's first nights in the Outback, we camped at Barrow Creek. This place is on every map, even though it is nothing more than a gas station. We were welcomed to this outpost with a downpour that left four inches of rain and even deeper red mud. Should it have surprised us when the family who operates the gas station told us it had not rained there in 13 years?

During the night, they had taken their two pet kangaroos indoors for fear that the storm would frighten the animals. It may have been the storm or my unexpected arrival at the house that caused one of these fascinating animals to hop through an open door into my arms. So there I was, holding this excited kangaroo, hoping its master would come to my aid.

The Stuart Highway is strewn with the carcasses of kangaroos and other animals killed by the monstrous road trains, which, having no chance of slowing down as they cruise at 100 miles per hour (there are no speed limits in this part of Australia), simply plow aside any animal unfortunate enough to get in their way. The cabs are fitted with "roo bars"—gratings of two-inch-diameter steel pipes —that enable them to hit animals as large as cattle and water buffalo without being damaged. Both are numerous in the Outback; the road carnage made that clear.

Road trains closing in on our safari at a relative speed of 150 miles per hour took their half of the highway out of three-quarters of the road. The Stuart Highway is two lanes wide in most places, so you don't play the road game of chicken—or kangaroo—unless you are prepared to end up alongside the unfortunate animals themselves.

The weather during the Solar Challenge was unusually cloudy and wet for a late Australian spring. It's impressive to see solar cars rolling in the sunshine—sleek, quiet and smokeless. It's even more impressive to watch them cruising under clouds—not too fast, of course, unless they are drawing upon the solar-charge of their batteries.

Because this much-needed precipitation coincided with the race, Australia's farmers are probably praying for the return of these strange vehicles again next year. Actually, the next Challenge race is not scheduled until 1990.

I CANNOT FINISH relating to you my impressions of the Australian Odyssey without telling you about Hans Tholstrup, the Solar Challenge organizer. It is now universally recognized that this single

event has created the greatest degree of public awareness of solar photovoltaics in the 30-year history of the technology. In Tholstrup you will find a nonengineer, nonscientist who has shown us a vision of the future of engineering and science.

Tholstrup was raised in a wealthy Danish family with roots in cheese and wine-making. By his own admission, Hans did not fit into the scheme of what he might call passive education. Instead, he has created his own brand of education, lifelong learning through what most of us would call high adventure. Once, he piloted a speedboat solo from Denmark across the Atlantic to Maine, stopping only to refuel in Iceland and Newfoundland. He holds the record for circling the globe in the smallest aircraft ever to achieve that feat—after taking a total of 10 days of flying lessons from six of the best pilots in the U.S. He has sailed around the Australian continent in a small boat and, about two years ago, he became the first to drive a solar car across Australia from west to east.

Currently, Tholstrup is planning a solo trek to the South Pole using a "solar dogsled." He says he will be ready to go in January 1989, during a month when the sun never sets in Antarctica. The vehicle will be totally solar powered. He will carry kerosene only to melt snow for drinking water and cooking.

At one point during the race, Hans and I traveled together in his sports car at a speed that reflects his lifestyle while we searched for two of the Australian cars approaching Adelaide. During our ride, he told me that he became an Australian citizen about 10 years ago, in part to fight what he considers to be rising socialism there.

Tholstrup's view of life is that if it's not exciting, perhaps it's not worth living at all. He argues that day-to-day life is not ordinary if you try to create positive change in that life.

In response to Hans Tholstrup's vision and initiative, GM has been able to create a solar car using the most advanced technology in all elements of vehicle design and to create what is a major contribution to humankind.

Somewhere in the Outback, Tholstrup compared GM's achievement to that of the Wright brothers. "It's simply as important as that," he said. "GM has done for energy efficiency what John Kennedy did for the space program. It's a little awesome."

Edward Clarke is director of the WPI Center for Solar Electrification and professor of engineering science.

At a pit stop, Sunraycer *shows off its unusual profile to a crowd of spectators.*

Ed Clarke: Still Blazing New Trails

As solar cells draw their power from the sun, Ed Clarke seems to get his energy from the power of new ideas and the exploration of uncharted territory.

In 1950, after receiving an undergraduate degree in engineering from Brown University, two master's in applied physics from Harvard and a Ph.D. in physics from Brown, Clarke joined Sylvania Electric Products, Inc., as a member of the technical staff working on semiconductors.

Back then, semiconductor science, the foundation of modern electronics, was a new field, and Clarke was one of its founders. He became a group head for research at Sperry Rand Corporation's semiconductor division, and in 1959 helped found the National Semiconductor Corporation, where he served as vice president until 1965.

Along the way, Clarke's work stayed on the leading edge of this rapidly advancing field of electronics. He led in the creation of transistors that helped make possible the first test launching of the Minuteman I missile as well as electronic devices incorporated in the F-104 fighter aircraft.

He led the team that produced the world's first mass-produced integrated circuit. ICs, also called microchips, made possible everything from digital watches to personal computers. His work earned him three patents, including one for a basic method used by the entire semiconductor industry for manufacturing transistors and integrated circuits.

Clarke joined WPI in 1965. As director of research and associate dean of graduate studies, he helped start a program of scholarship and graduate studies that continues to grow today. It was as research dean that he caught the solar bug.

In 1975, in the wake of the first national energy crisis, he worked to interest WPI faculty in solar energy research. When it became clear that the federal government intended to establish a national Solar Energy Research Institute, he lent his efforts to the drive to bring the lab to Massachusetts.

When he began to think about stepping down as dean, Clarke saw a chance to devote himself full time to students and solar power, which he believes can impact society as significantly as the semiconductor did.

As founder and director of the Center for Solar Electrification, he directs student projects in solar photovoltaics. Under his guidance, WPI undergraduates have carried solar arrays and the wonders of solar energy to the far corners of the world, from the Penobscot Indians in Maine to remote mountain huts along the Appalachian Trail.

Clarke reports that interest among WPI students in his solar car adventure has run high. In response, he has created nine new projects related to solar cars and worldwide solar car competitions. —Michael Dorsey

COMMUNIQUÉ

Do We Need Leadership in Higher Education?

By Dr. Jon C. Strauss

Leadership. It's a concept that's being talked about a lot nowadays in business and government. It's natural to wonder whether leadership is also something we in higher education should be thinking more about.

With the inertia of the tenure system, the lack of authority in collegial governance and the many disparate performance measures imposed on colleges and universities, we must question the role, form and effectiveness of leadership in the college and university environment.

John W. Gardner, founder of Common Cause, says leadership is "the empowerment of others." By empowering, leaders reinforce worth, develop competence, foster community and, most important, assure enjoyment.

However, leadership has its risks. The popular image has a charismatic leader on a white charger out in front of his troops. But the troops aren't always happy when they recognize that only the leader gets a change in scenery. Clearly, part of a leader's role is gaining acceptance among the troops for the rewards of their success.

Three specific leadership challenges for colleges and universities, Gardner notes, are fostering leadership, encouraging educational breadth and developing intuitive understanding of the culture.

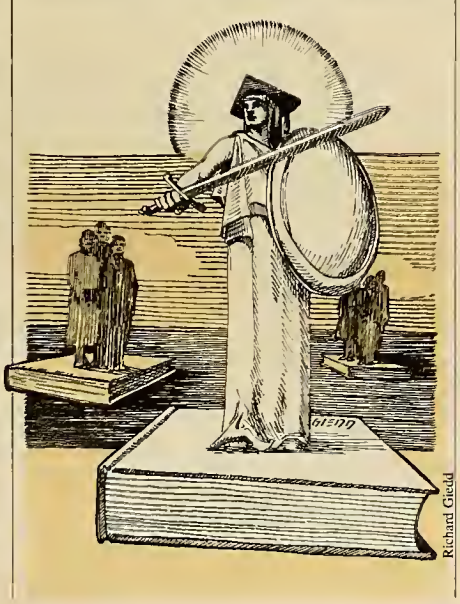
At WPI, we have met these challenges successfully in our undergraduate program. Through the Humanities Sufficiency and the Interactive Qualifying Project, the WPI Plan develops breadth of interest and a fundamental grounding in American culture. And the project system, with its team organization, builds leadership skills.

One of my greatest pleasures as president of WPI is listening to the rave reviews our students receive from corporate recruiters, employers and graduate school deans. They laud our graduates for their problem-solving and communication skills, but they are especially complimentary of their ability to lead and of their confidence. These observations are reinforced by the remarkable career success of our graduates.

The WPI Alumni Association has profited from and has played a major role in developing the outstanding leadership skills of its officers and its Council and Fund Board members. Service as trustee also provides ample opportunity for leadership development for the benefit of WPI. And WPI has benefited significantly from the leadership of its past presidents, deans and officers.

However, it is in the faculty of WPI where I see the greatest past success and the greatest future promise for leadership. Two decades ago, the faculty demonstrated remarkable innovation and dedication in developing and implementing the Plan. They met all the challenges of leadership except one. Although the Plan has had a significant influence on educational thinking, it has not been imitated.

Warren Bennis, former president of the University of Cincinnati and a scholar of leadership, said that "managers do things right, leaders do the right things." The Plan was the "right thing" for students, though it proved so costly in faculty effort that no other institution has found it possible to adopt.



Richard Giedd

While the Plan has been one of our most successful demonstrations of faculty leadership, it is also the cause of our greatest leadership challenge. Partly because of the time demands of the Plan and partly because of the rewards of its perfection, some of our faculty drifted out of the mainstream of scholarship and research during the 1970s. Fortunately, in the early 1980s, other faculty members recognized that the Plan could only be sustained by active faculty scholarship and spoke out for a greater emphasis on scholarship and research.

Their demands led to the hiring in 1984 of Richard H. Gallagher, provost and vice president for academic affairs, and myself in 1985. We have been actively engaged since then in helping faculty members realize their ambitious plans for improving scholarship while retaining and enhancing the Plan. A number of quantitative indicators demonstrate significant initial success.

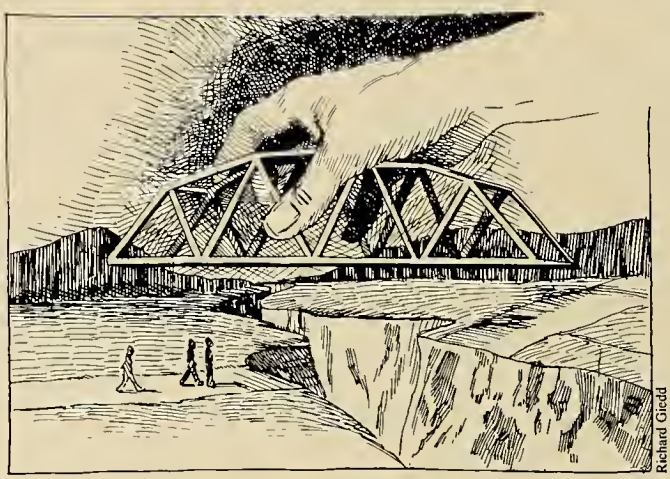
Well, this brings us full circle. I began by asking whether leadership makes a difference in higher education. The answer has to be a resounding yes!

As most members of the WPI family know, we are now engaged in the task of raising $52.5 million over the five-year period ending on Founders Day, November 11, 1990—the 125th anniversary of the founding of WPI. The *Campaign for Excellence* will provide the resources needed to reinforce the inherent quality of the Plan and build excellence in scholarship and research. We all stand to gain from this endeavor and, consequently, we all will be called upon to play a leadership role. I know we can count on you.

Jon Strauss is president of WPI.

Worcester's Minority Students See Their Hopes Rise on WPI's COMET

By Denise R. Rodino


Richard Giedd

Across the country, institutions like WPI are searching for ways to attack the nation's critical shortage of minority engineers and scientists. WPI's 100 minority students make up just under 4 percent of the undergraduate student body, a figure all agree is unsatisfactory.

In the fall of 1985, a group of WPI faculty members began to ask how the school members could attract more minority students. Their conclusion echoes the results of national surveys: Most minority students do not get the training or encouragement they need to pursue careers in technology and science. There is simply no pool of minority students for WPI to draw on.

Nationwide, the solution would seem to lie not in better college admissions recruiting, but in attacking the problem at its source by preparing minority students to attend college.

This realization gave birth to Career Opportunities Merging Education and Technology (COMET). Working with the Worcester public schools and a Worcester-based organization called ALPA (the Latin-American Progress Association), WPI faculty designed a program to help educate junior and senior high school students and motivate them toward college enrollment and, ultimately, careers in science and engineering.

In 1986, a $30,000 grant from GTE Corporation's Focus program brought the plan into reality, and two subsequent grants from the Massachusetts Board of Regents, totaling $145,000, have helped broaden and refine it.

Today, more that 20 WPI students—undergraduate and graduate—work with 60 Worcester high school students and 60 students from the Burncoat Middle School. COMET Director Bruce Young-Candelaria began using WPI students when it became apparent that what younger students need most is individual attention, not lectures, field trips, or even remedial classes.

In the high schools, WPI students work after school two days a week as tutors. During two-hour sessions, they help students with homework, teach basic concepts and work on their charges' English skills. They also serve as role models and friends.

"We seek to create both an academic and a social atmosphere," Young-Candelaria notes, "where students and tutors can exchange impressions about high school and college life and talk about career opportunities."

In the middle school, COMET is a teaching rather than a tutoring program. WPI students use classroom time and innovative demonstrations to give students individualized instruction in computer science. One project, for example, involves building a Heathkit robot that will become the school's mascot. As they help with the assembly, students get a rare glimpse into the workings of a robot and its computer brain.

At the high school level, both tutors and students are paid for their efforts, a practice Young-Candelaria staunchly defends.

"These students can drop out of high school today and make $5 to $6 an hour doing menial labor at any of the warehouses down the street," he notes. "Of course, most of them will still be in the same job 10 years from now, but high school students don't often think that far ahead."

By paying students for their attendance, Young-Candelaria says, "we're telling them their time is valuable and nothing is of more value than an education."

Like a job, the program makes demands on students. They must demonstrate motivation to their teachers and guidance counselors before they are accepted into the program. Once enrolled, they are paid by the hour and fired for poor attendance, or if their motivation or work ethic falters.

The program's success is judged by increases in such standard measurements as grades and test scores. Both tutors and students say it seems to be working.

What's next? Young-Candelaria would like to see a summer camp develop from COMET. WPI Professor Susan Vernon-Gerstenfeld, who began working with COMET this year, hopes to involve IQP students in research relevant to the program.

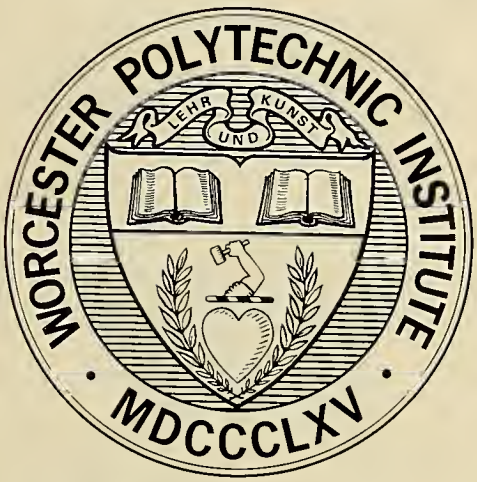
With two years of "graduates," it is now possible to begin tracking the success of the students. This information will help in planning the future of the program and ensuring that COMET will not only continue to benefit tutors and their students, but also that WPI will continue to contribute to meeting a national challenge.

Denise Rodino is director of foundation relations at WPI.

WPI Marks the First Century of Alonzo Kimball's Seal

By Roger N. Perry Jr. '45

"We never have been able to learn why the school has not adopted a seal. We were once shown the 'thing' on the back of the catalog and assured that it was a seal."
The W.T.I., a monthly WPI student publication, February 1887



With those words, a group of student editors threw down the gauntlet to the WPI community, seeking to set right what they saw as a longstanding wrong. Though the college was 22 years old, it had yet to adopt an official college seal.

Change was in the air in 1887. The college had only recently changed its name from Worcester County Free Institute of Industrial Science to Worcester Polytechnic Institute. (While the school was known informally as Worcester Technical Institute for several years—a name adopted by the student publication quoted above—this name was never officially approved.)

Many students responded to *The W.T.I.*'s challenge by submitting proposals for a seal. But it was Professor Alonzo S. Kimball, the popular head of physics and electrical engineering, who developed the seal which was adopted by the Board of Trustees in 1888, 100 years ago this year.

Kimball's seal included several key elements, most notably two open books, an arm and hammer, a heart, and a banner with the German motto *Lehr Und Kunst* (Learning and Skilled Arts). In *Seventy Years of the Worcester Polytechnic Institute*, Herbert F. Taylor '12 described the symbolism of these items:

> The heart is from the seal of the City of Worcester, the Heart of the Commonwealth. The German motto was selected to indicate the combination of academic learning, also symbolized by the books, and practical arts, symbolized by the arm and hammer. The latter device was adopted at the opening of the Institute in 1868. The use of a German legend was probably due to the vogue of that language in the '80s.

For an official date, Kimball chose 1868, the year the Institute opened. The stained glass window on the west end of Boynton Hall was based on this design and includes this date. In later versions of the seal the date was changed to 1865, the date of the Institute's founding.

Kimball's seal has undergone other changes over the years. Several typefaces have been used and the seal has appeared with "fluting" around its edge, representing the pattern left when a seal is pressed into sealing wax. And in the early 1960s, the German motto on the seal printed on some sweatshirts sold in the WPI Bookstore had degenerated into nonsense.

When the college prepared to celebrate its centennial in 1965, it was decided to establish an official version of the seal, which, while not copyrighted, is a trademark of the Institute.

With the help of an artist, a standard seal emerged. Actually, three standards were decided upon, varying only in the amount of detail. The larger the intended size of the printed seal, the more detail it contains.

While it was the lack of a school seal that most vexed WPI students in the 1880s, they also lamented the absence of school colors. After watching a football game in 1886, a student wrote a letter to the editor of *The W.T.I.* He noted that members of the opposing team all wore uniforms of the same color. At WPI, he said, it was traditional for each class to choose its own colors, causing confusion for football fans.

While details of the adoption of school colors are vague, a choice was made. Long fabled in college songs as crimson and gray, the accepted colors are actually maroon and gray.

As the seal was being formalized in the 1960s, standards were also set for the colors. Preserved in the Alumni Office were two pieces of antique ribbon considered to represent the original choices. These were matched with standard color samples used by printers.

It seems clear that Professor Kimball never intended for the seal itself to be reproduced in color. Still, attempts have been made over the years to design a full-color version. The Boynton Hall stained glass window and the carved wooden seal in Harrington Auditorium are two examples. Though they differ significantly in color, both are considered official.

It's been 100 years since WPI embraced Professor Kimball's seal. Most aspects of college life have changed since then, but this seal has remained a standard that still boldly proclaims WPI's guiding principles.

Roger Perry is director of campaign communications at WPI.

FINAL WORD

After two years in the mountains of Nepal, Dan Laprade '85 ponders culture shock, values and human obsolescence

By Amy Zuckerman Overvold

It is a long way from the mountains of Nepal to the high-pressure, high-tech corporate world of America.

Just ask Dan Laprade '85. He returned this winter from a two-year stint designing and building water systems with the Peace Corps in the highest nation on earth and is still reeling from culture shock.

"I haven't touched a computer in two years," he sighs, neatly delineating the problems engineers can face making the transition from work in the Third World to employment in an industrial society. While the work he did in Nepal was useful and fulfilling, he says it was also a far cry from the technologically advanced jobs he set his sights on when he returned.

Laprade's two years in Nepal were a real push-and-pull for a young man "looking for a challenge." He worried frequently about slipping behind technologically, but the needs of the Nepalese—and the rewards of making a contribution—would pull him back. In fact, they almost kept him there.

Laprade was in the middle of inspecting water projects when his tour ended. Wanting to see his work through to completion, he thought about signing up for another two years. Peace Corps veterans urged him to reconsider, explaining that there would always be more work to be done no matter how long he stayed.

And Laprade began to wonder what he would say to an employer if he hadn't touched a computer for four years. "What if I am obsolete at the age of 28?" he would ask himself. He decided it was time to come home.

Despite his worries, Laprade says he wouldn't have traded away his years in Nepal.

"When I graduated from WPI," he says, "I could have gone the hectic, corporate avenue. I could have, but I thought Nepal would be a challenge."

It was, though not in the ways Laprade had expected. He said life in Nepal is slow and seems inefficient to an outsider. Yet this environment forced him to be creative and constructive and to take the initiative.

"When I graduated from WPI, I could have gone the hectic, corporate avenue. But I thought Nepal would be a challenge."

Most of his WPI education proved far too advanced for the simple water systems he designed or inspected in outlying villages. But he found value in doing something that "wasn't a textbook thing."

He also learned something about hard, manual labor in the mountains of Nepal. Laprade was assigned the task of bringing water to a remote village near Yasuk, where the inhabitants had previously spent three hours a day fetching water.

In the absence of trailers, workers carried piping on their backs through miles of rugged terrain. To keep the pipes below the frost line, Laprade's crew dug 30-inch trenches in ground often the consistency of concrete without the benefit of jackhammers or backhoes.

The work wasn't as arduous as it sounds, Laprade says, nor was it the hardest part of his time in the Peace Corps. Far more trying, he says, was adjusting to "taking things as they come" and making decisions he did not feel qualified to make.

And Laprade says he got used to the food and to sleeping in huts, but he never quite got over his homesickness. "People draw you back," he says. "There isn't much social life in Nepal. You always desire to see your family and friends again."

As remote as his Nepalese village was, it wasn't too isolated for one of Laprade's WPI classmates to visit him, as Geoffrey Strange did in 1986 during a tour of Asia (for more, see *TheWire*, spring 1987).

As his time in the Himalayas wore on, Laprade says he "dreamed of settling down and getting established [in the United States]. I thought of getting a nice job and making money. Of being comfortable."

Since he has been back, he has thought of working with international organizations or corporations. International development work was also an option, he says, adding that recruiters have told him "the ball is in your court." "The Peace Corps experience," Laprade says, "gives me something above a new graduate."

For all his concerns about becoming obsolete, Laprade says joining the Peace Corps "was the best thing I could do. I got a chance to step away from my culture and put things in perspective."

And, he says he can better appreciate why the United States is a major power. Although he dislikes the hectic pace of corporate America, he can see "that's why we are the country we are" and why the laid-back attitude in countries like Nepal only serves to perpetuate Third World poverty and suffering.

If he could, Laprade says he would combine the best of both worlds—coupling the serenity of the Himalayas with American drive. For now, though, he will be happy just to have a job.

Amy Zuckerman Overvold is a free-lance writer living in Worcester.

Above: Dan Laprade '85 lectures to schoolchildren in the Nepalese village where he lived for two years as a Peace Corps volunteer. Below: villagers untie pipe to be used in the water systems Laprade designed and helped build.

EXCELLENCE IS... Merl Norcross,

Veteran Track and Field and Cross Country Coach

Men's track and field teams coached by Merl Norcross have enjoyed 20 consecutive winning seasons, two of those undefeated.

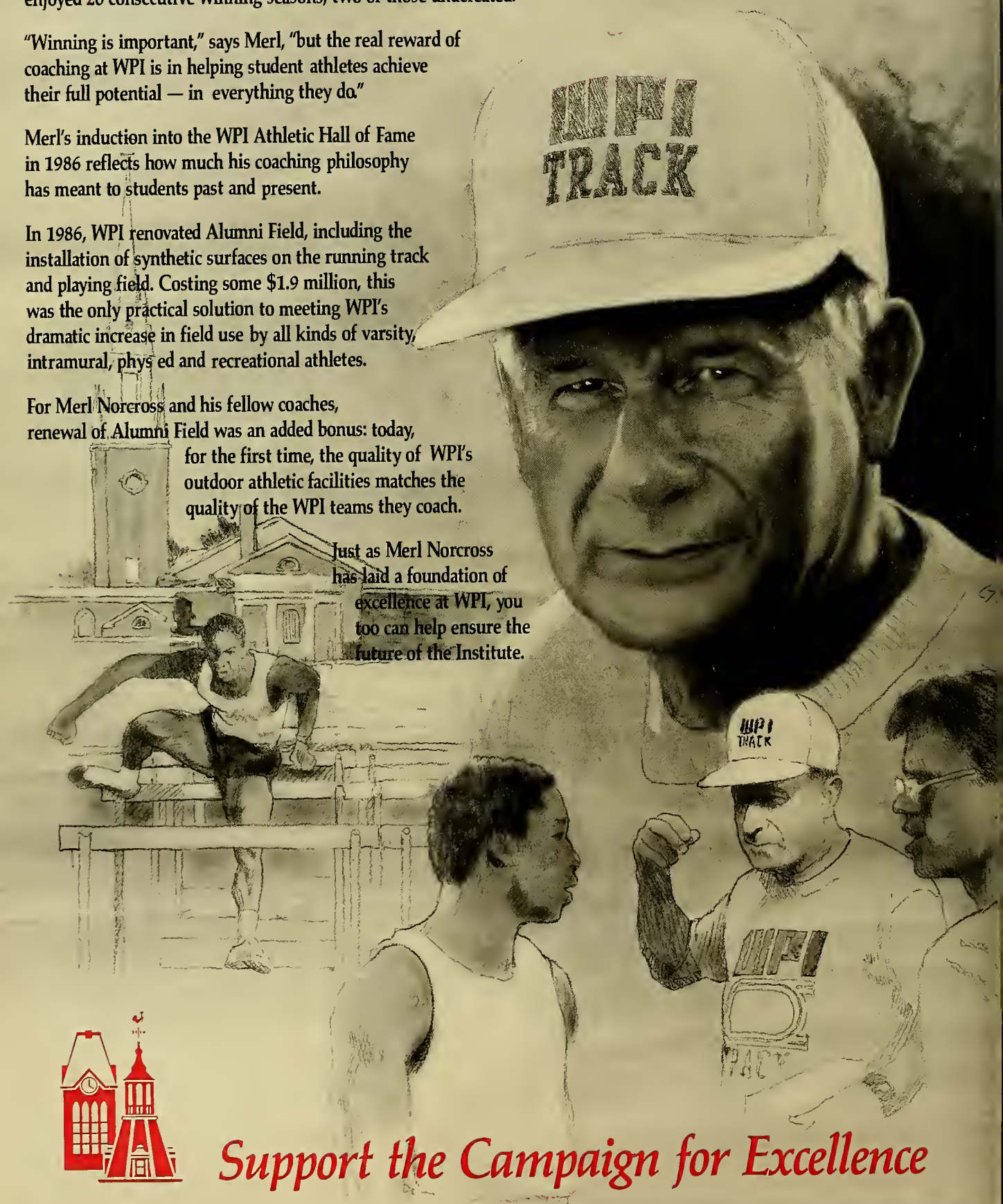
"Winning is important," says Merl, "but the real reward of coaching at WPI is in helping student athletes achieve their full potential — in everything they do."

Merl's induction into the WPI Athletic Hall of Fame in 1986 reflects how much his coaching philosophy has meant to students past and present.

In 1986, WPI renovated Alumni Field, including the installation of synthetic surfaces on the running track and playing field. Costing some $1.9 million, this was the only practical solution to meeting WPI's dramatic increase in field use by all kinds of varsity, intramural, phys ed and recreational athletes.

For Merl Norcross and his fellow coaches, renewal of Alumni Field was an added bonus: today, for the first time, the quality of WPI's outdoor athletic facilities matches the quality of the WPI teams they coach.

Just as Merl Norcross has laid a foundation of excellence at WPI, you too can help ensure the future of the Institute.



Support the Campaign for Excellence

WPI Journal

SUMMER 1988

THE NEW WO

The ivy-covered walls of the Higgins House garage. Photo by Michael Carroll. Black-and-white, 8-by-10-inch prints of this photo are available; send $10 to WPI Journal, 100 Institute Road, Worcester, MA 01609.

WPI JOURNAL

VOLUME XCI NO.5
SUMMER 1988

Staff of the WPI Journal: Publisher, Kenneth L. McDonnell • Editor, Michael W. Dorsey • Alumni Information Editor, Ruth S. Trask

Alumni Publications Committee: Samuel Mencow '37, chairman • Paul J. Cleary '71 • Judith Donahue, SIM '82 • William J. Firla, Jr. '60 • Maureen Sexton Horgan '83 • Carl A. Keyser '39 • Robert C. Labonté '54.

The WPI Journal (ISSN 0148-6128) is published quarterly for the WPI Alumni Association by Worcester Polytechnic Institute in cooperation with the Alumni Magazine Consortium, with editorial offices at the Johns Hopkins University, Baltimore, MD 21218. Pages I–XVI are published for the Alumni Magazine Consortium [Johns Hopkins University, Villanova University, Western Maryland College, Western Reserve College (Case Western Reserve University), Worcester Polytechnic Institute] and appear in the respective alumni magazines of those institutions. Second class postage paid at Worcester, MA, and additional mailing offices. Pages 1–16, 33–48 © 1988, Worcester Polytechnic Institute. Pages I–XVI © 1988, Johns Hopkins University.

Staff of the Alumni Magazine Consortium: Editor, Donna Shoemaker • Wrap Designer and Production Coordinators, Amy Doudiken Wells and Cecily Roberts • Assistant Editors, Julia Ridgely and Sue DePasquale • Consulting Editors, Alan Sea and Elise Hancock • Core Designers, Allen Carroll and Amy Doudiken Wells.

Advisory Board of the Alumni Magazine Consortium: Johns Hopkins University, B.J. Norris and Alan Sea • Villanova University, Eugene J. Ruane and D.M. Howe • Western Maryland College, Joyce Muller and Sherri Kimmel Diegel • Western Reserve College, David C. Twining • Worcester Polytechnic Institute, Michael Dorsey and Kenneth L. McDonnell.

Acknowledgments: Typesetting, BG Composition, Inc.; Printing, American Press, Inc.

Diverse views on subjects of public interest are presented in the magazine. These views do not necessarily reflect the opinions of the editors or official policies of WPI. Address correspondence to the Editor, The WPI Journal, Worcester Polytechnic Institute, Worcester, MA 01609. Telephone (508)831-5616. Postmaster: If undeliverable please send form 3579 to the address above. Do not return publication.

CONTENTS

8 **Worcester Makes a Comeback** *Amy Zuckerman*
The former mill town is fast becoming a modern city.

I **Electronics in the Body Shop** *Marshall Ledger*
A new generation of implants will replace human parts.

VIII **The day Nixon broke into the office of the dean** *Ken Sokolow*
. . . and other anecdotes from presidential college days.

XII **Photo Winners**
Results of our contest for readers.

33 **The Shape of Things to Come** *Paul A. Susca*
Stretching the limits of engineering computation.

40 **The Myth of High-Priced Higher Education** *Jon C. Strauss*
The numbers tell a different story.

44 **The Entrepreneurial Spirit** *Michael W. Dorsey*
Ron Howard '77 launches a successful software company.

Page 4

Page 8

Page 1

Page 44

DEPARTMENTS

2 **Advance Word:** Goodbye "Wormtown." *Michael W. Dorsey*

3 **Communiqué:** Tuition hikes: behind the scenes. *Jon C. Strauss*

4 **Input:** The lesson of the Japanese miracle. *John F. Zeugner*

5 **Inside WPI:** Reaching out to the world. *Kenneth L. McDonnell*

6 **Investigations:** New applications for inorganic membranes.

7 **Explorations:** Making safer baby walkers; photography pioneers.

47 **Memory Bank:** The naval invasion of WPI. *Roger N. Perry, Jr.*

48 **Final Word:** The science of making music. *Bonnie Gelbwasser*

Cover: The old and the new Worcester contrast in this view of City Hall reflected in the Shawmut bank tower. Story on page 8. Photo by Robert Arnold.

ADVANCE WORD

Goodbye "Wormtown"

Work progresses at the site of Fuller Laboratories. (See the back cover for an artist's rendering of the new building.)

By Michael W. Dorsey

Not long ago, rock superstar Bruce Springsteen came to Worcester to launch his latest national tour. Because his appearance at the Centrum was the first opportunity for the national press to sample the Boss's "Tunnel of Love Express," Worcester, for a few days, became the entertainment capital of America.

Many of the reporters who converged on Worcester that weekend were seeing New England's second-largest city for the first time. A few, like *New York Times* reporter Allan Gold, put their impressions in writing.

In an article that asked "Bruce, why Worcester?", Gold noted that some have called the city a "dreary backwater whose sole attraction is its proximity to Boston." He summed up Worcester as a "gritty central Massachusetts mill town."

Gold was the second *Times* reporter to disparage the city in just six months. In an earlier piece, Matthew Wald, writing about the 175th anniversary of the Worcester-based American Antiquarian Society, noted: "Aiding in the low profile of the Society is its improbable location. Boston, with its many colleges, clearly can lay claim to being the nation's library.

"By contrast, Worcester, a former railroad center with such industries as cardboard box manufacturing and metalworking, can be considered Massachusetts' utility closet."

That didn't sit well with city residents, hardline supporters and critics alike. Letters were fired off to the *Times* editors. Worcester was not going to take such abuse anymore.

That Worcesterites got hot under the collar is expected. That they did something about it is not. For many years, Worcester has been content to sit back while the world passed it by on the way to Boston, Hartford and Providence. But things are changing. There is a new sense of excitement in the air in Worcester. There is a refreshing sense of pride in a city some residents once called "Wormtown."

Culturally, economically, demographically and politically, Worcester is emerging from Boston's shadow and from its own inward-looking, industrial past. Our cover story by Amy Zuckerman, a lifelong Worcester resident, looks at these changes and how they have transformed the city. Robert Arnold's stunning photographs offer full-color proof of the dramatic rebirth of the city's downtown.

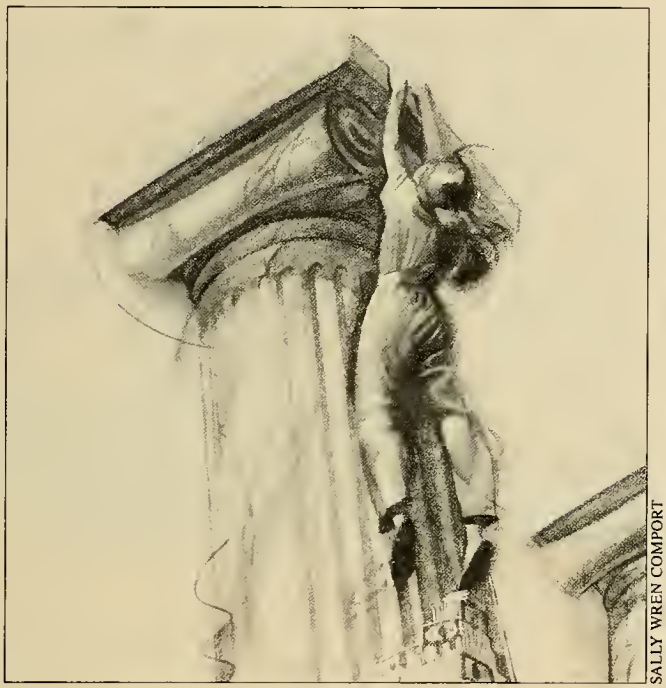
Worcester has not been alone in its efforts to spruce up. Over the last decade, WPI has been at work transforming its campus. These changes have included the installation of a synthetic surface on its athletic field and track, and the addition of Founders Hall, a new residence complex that won the 1986 Export Award from the Boston Society of Architects.

In addition, the campus's two oldest buildings, Boynton Hall and Washburn Laboratories, received striking face-lifts, as did Salisbury and Atwater Kent Laboratories. Houses near campus have been restored and converted to offices for administrative departments. One house was recently turned into a new Campus Police station.

This summer, work began on the newest phase of the campus's metamorphosis, the construction of Fuller Laboratories. The future home of the Computer Science Department and the college's computer service operations, Fuller will soon rise on a triangular plot of land bordered by Atwater Kent, Kavin Hall and the Gordon Library. For more than a century, the growth and fortunes of WPI and the city whose name it bears have been closely tied. Somehow it seems fitting that once again city and college are moving forward together.

COMMUNIQUÉ

Tuition Increases: Behind the Scenes



SALLY WREN COMPORT

By Dr. Jon C. Strauss

In February, WPI's Board of Trustees voted to increase tuition and fees to $12,000, an increase of 11.1 percent—well in excess of the increase in the Consumer Price Index. This has led many to ask not only why this increase was needed, but how the price of a WPI education reached its current level and where it is likely to go in the future.

As parents of a young child, Jean and I find these questions particularly compelling. If tuition and fees continue to increase at their recent average rate of 10 percent per year, by the time our son, Kristoffer, matriculates at WPI in the fall of 2005, tuition and fees will be $60,650. By his senior year, that cost will have risen to $80,750. I don't want to dwell on my own situation, but it illustrates the kinds of concerns students and their families are going through now, and what the families of our future students will face.

Beginning on page 40 is an article I wrote that explains how we got to our current tuition levels, how our increases in expenditures have been consistent with our stated mission and how they are compatible with those of other institutions. The article shows that over the 10-year period beginning in 1975–76, WPI's expenditures increased by some three percent more per year than the Consumer Price Index, while tuition and fees increased about four percent per year above the index.

The article does not, however, address the role that institutional competition, particularly between private and public schools, plays in increasing the cost—and price—of a college education. Nor does it focus on the question of what is likely to happen to tuition in the future.

One of the principal reasons higher education in the United States is the envy of the world is that U.S. colleges and universities are engaged in fierce competition for students, faculty, dollars, and, more importantly, academic quality.

However, competition for students is seldom based on price, but almost always on quality. The key to quality is investment in new people and programs and reinvestment in the existing high-quality facilities of the institution. Hence, competition is forcing price increases rather than cost controls.

Still, the questions remain: Why is tuition increasing this year by about seven percentage points more than the Consumer Price Index? And what does this say about future increases? The answers are threefold: benefits, financial aid and new equipment.

The cost of providing employee benefits is increasing more than 20 percent this year due to extraordinary increases in health care costs and the federal mandate to equalize benefits for all employees. Both these factors should have less impact next year.

Over the last two years, we have increased our financial aid budget substantially to meet the full needs of, first, the freshman class, and now the freshman and sophomore classes. This policy will apply to three classes in 1988–89.

We believe this policy is vital to our efforts to continue providing access to a WPI education for students from the middle economic spectrum, who have for so long been the mainstay of our student and alumni bodies. Unfortunately, it has proved very expensive to expand this policy at a time when federal and state governments are cutting back on student-aid funds.

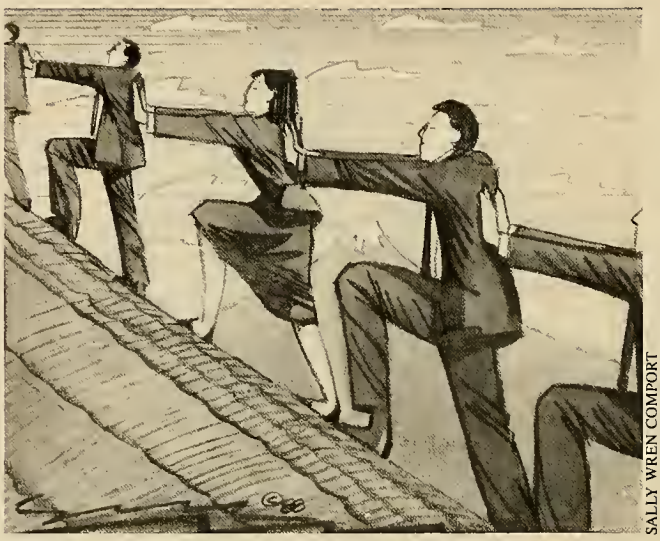
We are also involved in a major effort to improve student access to state-of-the-art laboratory equipment, as well as computers and telecommunications facilities. In time, these improvements will be funded by the *Campaign for Excellence*, but the faculty and trustees agree that this new equipment is needed now, even at the cost of higher tuition.

If this year's tuition increase was inevitable, what can we say about the future? The continuing expansion of the financial aid program will contribute to additional higher than average increases, though as income from the *Campaign for Excellence* grows, tuition increases will likely revert to the historical norm of about four percent above inflation. And if a new presidential administration can hold down inflation, it should be possible to keep tuition increases well below 10 percent while maintaining—and enhancing—the quality of a WPI education.

Jon C. Strauss is president of WPI.

INPUT

Why We May Never Learn the Most Important Lesson of the Japanese Miracle



SALLY WREN COMPORT

By John F. Zeugner

With no appreciable natural resources, more than 90 percent of its energy imported, and its industrial base leveled just 43 years ago, Japan—solely through the talent, industry and commitment of its people—has today achieved the highest per capita income of any industrialized nation and one of the world's most successful economies.

Many commentators say there are lessons that can be abstracted from Japanese culture which, if adopted, could spur a similar economic miracle here at home. Indeed, individual pieces of the Japanese approach have been transplanted to the United States with amazing results. But adopting those pieces may not be enough, for there is an important element missing—what the Japanese call *amae*. Literally, the word means sweet, but it has many connotations and may be best translated as the brilliant Japanese psychiatrist Takeo Doi did in the title of his book, *The Anatomy of Dependence*.

When I taught at Keio University in Tokyo, my students insisted that Western psychiatry had ignored the largest, most important element of the human psyche—the need for dependence, the desire to be in a hierarchical arrangement that enables one to depend on a superior in return for one's loyalty.

The most fundamental *amae* occurs, Doi argues, in the mother-child relationship, but the Japanese, recognizing its profound nature, recreate it in all interactions. That is why status is so important in Japan—in student-teacher relationships, in employee-company relationships and in citizen-nation relationships. Everywhere, the Japanese seek the security of *amae*, which unconditionally protects the inferior and gives to the superior absolute loyalty.

The concept of *amae* seems to puzzle Westerners. Most Americans are familiar with it only in negative contexts—for example, through the arguments of 19th-century defenders of the slave system. But, at least through sports, Americans are well acquainted with the notions of teamwork, subordination, hierarchy and mergence of role with self.

Amae provides a way of thinking about life in terms beyond the self and does it automatically. This orientation gives the Japanese a terrific edge in making choices, finding harmonies and establishing priorities.

At Osaka University, I taught a student named Yoshida who wanted to enter the foreign service, but failed his oral exam. His remaining choices included taking a position with the prefectural government of his home town, working for an electric company or entering a brand-new graduate school of business and government service for an intensive, three-year period of study in international economics and culture.

He wrote me asking what to do. I said the first two choices seemed, from what I knew of Japan, preferable. The school was a question mark. What companies or agencies would hire its graduates, since they would have an unknown status? And, conscious pursuit of internationalization seemed, in 1979 Japan, an aberrant act.

"After many weeks of consultation," he wrote back, "I decided to enter the school and to do my best in the long course of training. I felt this decision would be difficult, but it would be the best thing for Japan—even if now Japan does not know it. I am sorry to disappoint your advice."

It is the greatest failure of our education, of our society, of the tenor of our times, that we seem unable to grant to our students, if not the conviction of Yoshida's words, then the language of his expression. It is not that we have to buy into *amae* or some pale substitute, but that we rather desperately have to find ways, vocabularies, inclinations and motivations so we may pass along to the next generation, and our own, the ability to choose issues beyond the self, beyond independence, beyond immediate careerist, consumerist fascinations. The culture that provides deeply, automatically, unconsciously such mechanisms will survive. The rest of us will simply evaporate, despite our high or low technologies, our pleated or unpleated distractions.

John Zeugner is the Paris Fletcher Professor of Humanities at WPI. Between 1976 and 1978, he was Fulbright Senior Lecturer at Osaka and Kobe universities in Japan. He returned to Japan in 1981 to spend two years as visiting professor at Keio University.

INSIDE WPI

Reach Out and Touch Someone

By Kenneth L. McDonnell

One impact of technological development is the shrinking of the global neighborhood. Often it's the least developed cultures that are most at risk of losing their identity in the process.

Meanwhile, practicing engineers say their professional success now hinges more on their ability to work with people than on their design of innovative products.

It is squarely at this interface of technology and human interaction that many of today's key engineering challenges surface.

On Boynton Hill, the faculty's concerns over cross-cultural issues are at the heart of a new student project initiative. The Center for International Studies (CIS) comprises more than 20 members of the faculty whose cultural roots range from Denmark, Germany, Italy, Switzerland and the U.S., to India, Iran and Mexico.

CIS's chairman, Assistant Professor of Electrical Engineering Hossein Hakimmashhadi, a native Iranian, says the center was created to encourage cooperation among faculty members interested in advising Interactive Qualifying Projects (IQPs) focusing on cross-cultural studies.

The group is busy today identifying the areas of study to which WPI can make material contributions, whether they involve examining which technologies are appropriate for cultures with varying degrees of economic development or developing effective models of transferring technology between cultures.

CIS may be in its infancy, but international studies at WPI are as old as the Plan itself. The college has housed a project center in Washington, D.C., since 1974 and has conducted international exchange programs with several European technological institutes for nearly as long.

But now CIS is integrating WPI's cross-cultural focus and organizing international teams of students to tackle projects with global dimensions. For example, a team made up of U.S. and African students is applying solar technologies for villagers in Botswana. Closer to home, a project team of American and Malaysian students is bringing solar energy to the Penobscot Nation in northern Maine. And this fall, a number of IQPs will begin in Venice, Italy, addressing challenges like tidal monitoring and environmental quality.

Meanwhile, London is experiencing what might be called the WPI invasion of Britain. Growing out of the unbridled success of the two-year-old London Project Center, four teams of students spent the past summer in London working with public or private agencies to complete their IQPs.

One group worked at Lloyds of London assessing how computers are affecting the ability of the 200-year-old financial consortium to underwrite the world's riskiest ventures. Other teams, responding to Britain's concern over its ability to attract and keep students interested in electrical engineering, developed booklets for British children to promote the attractiveness of the field as a future profession.

Humanities Professor Lance Schachterle, director of the Division of Interdisciplinary Affairs at WPI and London Project Center codirector, says sponsoring agencies and other London organizations are so eager to have access to WPI students that this summer's British projects became necessary. Such interest may one day create the need for additional regular summer sessions at the center, he adds.

The London experience, says Schachterle, would not be nearly so successful if it weren't for WPI's professional contacts in the city. In almost every case, those contacts have come through Professor Maria Watkins, London codirector of the center. A lifelong Londoner, Watkins was the first woman to teach electrical engineering at the British university level and is today professor emeritus at The City University of London. In August, Watkins found herself boarding a chartered motor coach in Oxford to join 30 current and former WPI students for a three-week tour of England and Scotland. These were no mere tourists, though, but rather a troupe of WPI actors and producers whose ultimate destination was the fabled Edinburgh Festival, one of the world's most respected—and unpredictable—gatherings of theater, music, dance, art, sculpture and crafts.

Now in its 41st year, the Festival plays host to some 450 theater companies from around the world—everything from Shakespeare to vaudeville—for three weeks each August.

At several venues in the city itself, and for two weeks prior to their arrival in Edinburgh, Susan Vick, associate professor of drama at WPI, and her students performed more than a dozen of their own works, adapted from New Voices, WPI's annual festival of new theatrical works created and acted entirely by WPI students.

They performed, for example, in London, at places like Covent Gardens, where many famous actors have gotten their starts; and in Oxford, where they were housed at 16th-century Lincoln College. Along the way, the troupe spent a day in Stratford-on-Avon, visiting Shakespeare's home and sharing one of the world's foremost centers for art with thousands of other theater lovers.

And in Edinburgh, WPI joined hundreds of other performing groups in the Festival "Cavalcade," a parade of floats on which light, brief performances delighted thousands of spectators.

"I can't tell you how exciting this experience was for our students," Vick exclaimed upon her return, "—and for me!"

No doubt about it: WPI is truly making its presence felt "over there."

Enthusiasm Percolates through New Inorganic Membrane Center

Generally, before the product of a chemical or biochemical reaction can be used, it must be removed from the chemical soup in which it was formed and then concentrated. For this reason, separation and purification are two of the most fundamental processes in chemical engineering and biotechnology.

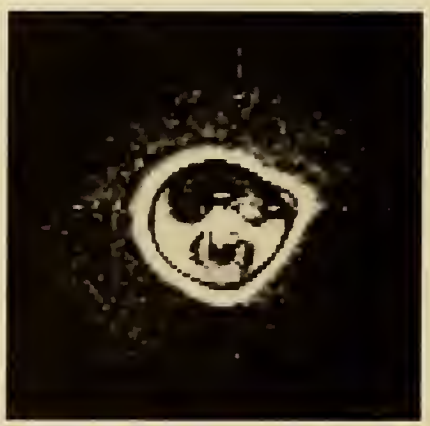
For many years, one of the basic technologies of separation and purification has been the membrane, a thin layer of organic or inorganic material with pores or channels that allow materials of certain sizes or chemical composition to pass through, while leaving everything else behind. Because they are better understood, membranes made from biological materials, particularly polymers, are now used in many industrial applications. But interest in inorganic membranes has run high in recent years, according to Yi Hua Ma, head of WPI's Department of Chemical Engineering.

Among the qualities attracting scientists and engineers to membranes made from inorganic compounds is their greater resistance to heat and chemical reactions. They have more uniform pores than their organic cousins and are less likely to become clogged.

These properties make inorganic membranes ideally suited for applications ranging from cheese making to water purification to waste treatment. They are even used to produce nonalcoholic wines by separating out the alcohol as the wine passes through.

But, Ma notes, despite their usefulness, knowledge about the properties of these membranes is "in an embryonic stage." Scientists know too little, he says, about how they work and how to engineer them to perform specific jobs. To address these and other questions, WPI recently launched a new Center for Inorganic Membrane Studies, the first research center at a U.S. university devoted exclusively to inorganic membranes.

The center, which currently has more than $130,000 in annual corporate support, consists of Ma, William Clark, David DiBiasio, Anthony Dixon and William Moser from WPI's Chemical Engineering Department, Ronald Biederman and Richard Sisson Jr. from the college's Materials Science program, and Paul Inglefield and Alan Jones from the Chemistry Department of Clark University.



This image of the fluid flow through the membranes of a biological reactor was made by scientists at WPI with magnetic resonance imaging.

The center grows out of existing research strengths at WPI, notes Ma, who serves as its director. In particular, WPI, through the efforts of several Chemical Engineering faculty members, has developed an international reputation for its work on zeolites, inorganic membranes made from silicon and aluminum that have important uses, particularly in the petrochemical industry.

Researchers at the center will focus their attention on six key areas of study. These include a look at how inorganic membranes form. Many commercial membranes consist of layers, including a support material and a thinner working membrane. The WPI researchers want to know how these layers bond together.

It is possible to deposit active catalysts on the surface of some inorganic membranes, allowing the membrane to both instigate a chemical reaction and separate out its products. The center's faculty want to know more about how catalysts work when attached to a membrane and how changes in the properties of the membrane affect the catalysts' performance.

One of the problems associated with all membranes is their tendency to clog or foul. Fouling can be caused by filtered material backing up in the pores or from the membrane itself crumbling and blocking the passage of fluid. Work is being done to pinpoint the causes of fouling and to model the flow of material through a membrane. Such a model will help researchers create the best membrane for each specific application.

Detailed studies of fluid flow through a membrane have proven difficult. One novel method for overcoming these problems is now under study at WPI. The technique tunes a magnetic resonance imaging (MRI) scanner to produce an image that shows, by the relative lightness or darkness of dots on a video screen, how fast fluid is moving at various points in a membrane. The technique should have widespread applications in the study of inorganic and organic membranes.

The use of inorganic membranes in biotechnology is another important area the center will address. One focus will be techniques aimed at binding proteins to the surfaces of inorganic membranes to produce biologically active systems.

The center, which counts Alcoa and Texaco among its members, wants to increase its base of corporate support.

"So far, our discussions with several companies have produced very positive results," Ma said. "With the addition of new members, and with government funding, we expect the center to become self-sufficient in about five years."

—Michael Dorsey

EXPLORATIONS

Taking Steps Toward a Safe Baby Walker

Major Qualifying Project by Scott D. Gallett '88 and Nicholas M. Werthessen '88
Advisor: Mohammad N. Noori, assistant professor of mechanical engineering.

Interactive Qualifying Project by Herman Purut '88, Peter S. Revelas '87, Michael J. Sasloff '88 and Vincent P. Solferino '88.
Advisor: Roger Y. Lui, assistant professor of mathematical sciences.

Baby walkers are hurting babies. Nearly 24,000 infants were injured by walkers during 1980 alone, according to the Consumer Products Safety Commission. In fact, walker accidents—toppling over, falling down stairs and objects being pulled down on the walkers—each year account for nearly 40 percent of all injuries caused by the class of children's products that also includes strollers, high chairs and car seats.

In the last decade, Dr. Louis Fazen, director of the Pediatric Emergency Room Service at St. Vincent Hospital in Worcester, MA, has conducted his own studies of baby walker injuries. They have led him to believe that the only solution is a new approach to walker design. For ideas, Fazen came to WPI.

Responding to Fazen's challenge, two teams of WPI undergraduates studied the problem and came up with very different solutions.

Purut, Revelas, Sasloff and Solferino decided to revise the traditional baby walker design, retaining the "X" frame common to many units, but equipping the walker with features designed to prevent accidents and injuries.

A key feature in their design is an ultrasonic range detector that senses when the walker is approaching a drop in level—the top of the stairs, for example—and locks the wheels while alerting nearby adults with an alarm.

MICHAEL DORSEY

Nicholas Werthessen and Scott Gallett with plans for their baby walker.

Other improvements include velocity-limiting wheel locks that control the walker's speed, a soft cloth seat that supports the child like a parachute harness and a redesigned folding mechanism that eliminates accidental collapsing.

Gallett and Werthessen focused their attention not just on preventing accidents but protecting babies in the event of a spill.

By modifying a popular child's toy made of tough plastic tubing and joints, they created a "cage" 16.5 inches square and 35 inches high. Connecting bars were added for rigidity.

Inside the cage is a harness suspended from all eight corners of the frame, into which the child is strapped and zipped. The harness supports the child's weight and absorbs shocks during a fall. The walker is also fitted with large wheels that easily roll over obstacles, minimizing tipping.

The students demonstrated the sturdiness of the design by placing a 25-pound weight in the harness and sending the unit rolling unharmed down a flight of slate stairs in WPI's Alumni Gymnasium.

The unit was also field tested by a nurse at St. Vincent Hospital who found the harness, once adjusted, easy to use, and she reported that her child had no difficulty in moving the walker around.

Dr. Fazen says the WPI student efforts go a long way toward ending an important hazard. "If we can go to the moon, certainly we should be able to create a safe buggy for our kids," he says.

A Look at Pioneer Photographers

A Humanities Sufficiency by Shawn D. Harrison '89
Advisor: Malcolm E. Parkinson, associate professor of history.

Nineteenth-century photographers like Joseph Nicephore Niepce, who produced the world's first photograph; Louis Jacques Mande Daguerre, inventor of the first widely used method of photographically preserving images; and William Henry Fox Talbot, who invented the first practical positive/negative process, laid the groundwork for the craft of modern photography.

For his project, Harrison delved into the history of photography and searched through treatises on inventors and inventions, looking for the influences that motivated each man.

He was able to show how each of the photographers was influenced, not only by his "craft" and by private motives, but by four forces of 19th-century culture: the movement toward naturalism the desire for linear perspective, the rising interest in tinkering and the fascination with illusion.

Each factor, albeit to varying degrees, Harrison says, was significant in "molding and kneading" the lives of the inventors. By analyzing these forces, "we have begun to understand the motivational processes behind the pioneers of photography, whose efforts had such far-reaching effects," he notes.

Harrison's project was one of three winners of the 1988 Class of 1879 Awards for outstanding Humanities Sufficiencies.

—Bonnie Gelbwasser,
WPI Student News Writer

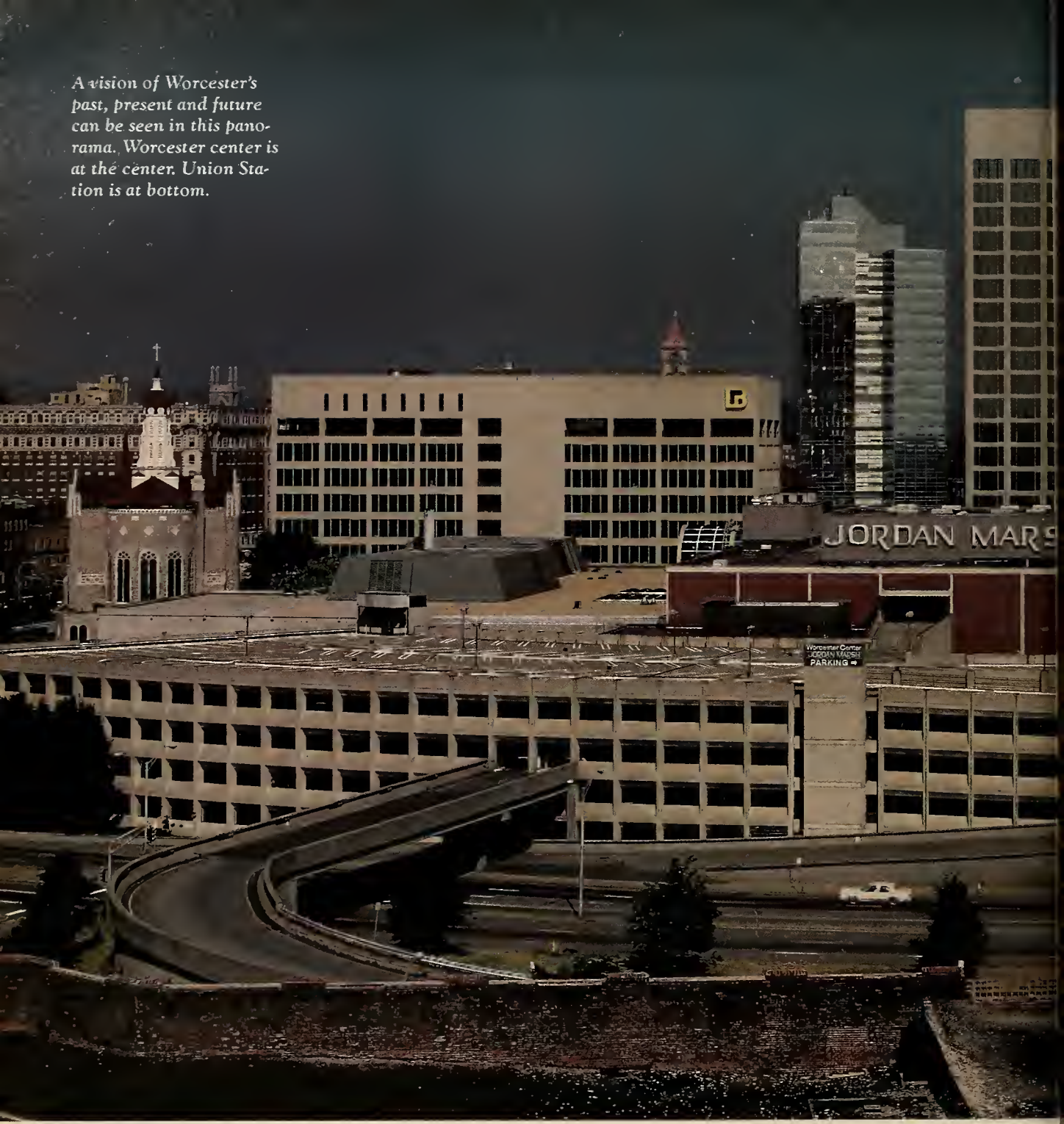
WORCESTER MAKES A COMEBACK

The Changes Are Dramatic, and Much More than Skin Deep, in New England's Second City

Photos by Robert S. Arnold

BY AMY ZUCKERMAN

Once dismissed as an aging mill town, Worcester is on its way to becoming a beautiful modern city.



A vision of Worcester's past, present and future can be seen in this panorama. Worcester center is at the center. Union Station is at bottom.

Much has changed in New England's second-largest city since the days when Raymond J. Perreault '38 and his classmates skied on Newton Hill and commandeered Institute Road for sliding during their winters at WPI.

Since Perreault, a Worcester native, left the city to found Falls Machine Screw Co. in Chicopee, MA, Worcester has lived through two major changes in city government, suburbanization, major highway construction, downtown urban renewal and the emergence of the city as a cultural center for central Massachusetts that rivals even Boston in the rock 'n' roll scene.

City Manager Francis J. McGrath, who served longer than any city manager in the history of the United States, is no longer in office, and local institutions like the *Worcester Telegram & Ga-*

zette have changed hands. Sometimes called "the gray lady on Franklin Street," the *T & G* was sold to the Chronicle Publishing Co. of San Francisco in the fall of 1986.

If not as strong as nearby Boston, Providence and Hartford in the public relations and communications fields—Worcester does not have a full-time television station offering local news and programming—the city is strong today in legal services, medicine and biomedical research (see the Spring 1988 *Journal* for more on Worcester's Biotechnology Research Park).

Alumni such as Donald G. Craig '57 and Edward L. Griffith Jr. '69 like what they see and hear of the new Worcester.

Craig says he and his classmates rarely explored the city beyond the limits of Lincoln Square, the site of a number of bars, including the popular Valhalla. He remembers the city as "a kind of run-down, shop-oriented, low-class type of place."

Like Craig, Griffith, who grew up in the neighboring town of Leicester, says his prejudice against the city kept him from seeing much of Worcester beyond Lincoln Square and Highland Street, the center of Worcester's 1960s counterculture. The rest of Worcester seemed "too limited" to bother with.

Both Craig, now a DC–10 captain for American Airlines, based in Connecticut, and Griffith, a vice president for Emcon Associates, a Cupertino, CA, waste management consulting firm, say they would have much preferred today's Worcester.

Returning over the years for alumni events, Craig has been pleased with the improvements in the appearance of both Worcester and the WPI campus.

"I've watched Worcester grow into a beautiful city," he says. "They've redone downtown and I can't believe how attractive the WPI campus is compared to when we were pounding away on our slide rules. As far as I'm concerned, there's hardly any resemblance to when I was first there."

Even their old hangouts have been transformed. Today, the bars are gone from Lincoln Square, replaced by a central police headquarters and the Marriott Hotel. And the head shops of Highland Street have given way to fashionable boutiques and restaurants.

The changes that have transformed Worcester are not just skin deep, though. Talk to government leaders and local citizens and you'll hear a new sense of pride in their city—in the way it's grown, and also in the way it has stayed the same. They will tell you that Worcester is a special place to live. Less expensive than Boston—the median price for a home here is $60,000 less than in the state capital—Worcester offers an easygoing lifestyle and community spirit often missing in bigger cities.

The "new" Worcester is the product of many factors. Part of the formula is the spirit and dedication of longtime city residents. Another is the fresh perspective and drive of a growing influx of young professionals.

The last two decades have seen a shift in Worcester's economy, from one based largely on industry to one driven by services, such as health care, biomedical research and education. Fueling this change have been the location of high-technology firms in Worcester suburbs and sky-high real estate prices in the metropolitan Boston area, which have helped attract professionals to Worcester.

There is evidence the newcomers have sweetened the Worcester economy. Since 1979, the median income in Worcester has risen 80 percent, to $32,600. The number of condominium units in the city climbed from 400 to nearly 2,000 during the last five years. New home starts, which averaged 30 to 40 per year before 1983, are now at about 300 per year.

The city has also seen a large influx of new residents of Southeast Asian and Hispanic descent in the last decade. This influx has been felt in the school system, where a battle over bilingualism rocked school committee meetings in the 1970s.

As the city's demographics

WGN
720

have shifted, a new, populist spirit has made itself felt in the city's government. The change began in the fall of 1985 with the retirement of Francis McGrath who, to many Worcester residents, was synonymous with city hall and the city manager form of government.

While McGrath was known for his ability to "pull rabbits out of the hat" in times of crisis, over the years Worcester citizens became increasingly restive with the McGrath administration and its ruling style.

Local observers of the political scene, such as David Rushford, first assistant city clerk, generally agree that the city charter adopted in the 1940s lent a feeling of inflexibility to the city government, as it had no provision for review—or removal by election—of the city manager.

One city councillor in particular reflected the feelings of many Worcester voters. Jordan Levy, a Jewish businessman who grew up in a poor section of Worcester's East Side, began in the early 1970s to push for change. With former City Councillor Paul Leahy, he spearheaded a drive for reform, which resulted in a new city charter's being passed by voters in the fall of 1985.

The provisions of the new charter include ward representation on the council, review of the city manager and the direct election of mayors. Last fall Levy, top vote getter in the last six municipal elections, became the city's first directly elected mayor in almost 40 years.

Levy is representative of what many see as a new breed of leader who has emerged in Worcester in the last decade. The latest crop of local movers and shakers is a diverse lot, represented by both sexes and a variety of religious, ethnic and racial backgrounds.

While working to create a modern skyline, Worcester officials and developers have also preserved the gems of the city's past, like the 19th-century office tower above. Among Worcester's most prized pieces of history is Mechanics Hall (l), considered one of the finest concert halls in the country.

They range professionally from medicine to law, from real estate development to insurance and the social service fields. What they share is an intense interest in Worcester and the community. Their goals include encouraging growth and development, while maintaining Worcester's small city ambience and lifestyle; seeing more women and minorities in power positions; balancing building with conservation of open space; strong regional planning; and increased corporate support for the arts.

While the impact of Worcester's shifting demographics and governing style will likely be felt far into the next century, Worcester has already changed in many remarkable ways.

City residents such as Donald Melville, former head of Norton Company and an avid supporter of the arts, say Worcester has truly become a cultural rival to Boston.

The most recent addition to the cultural horizon, and some would say one of the most significant elements in

Worcester's renaissance, is the Centrum, a multipurpose arena that opened in 1982. Each year the Centrum hosts dozens of large-scale indoor events, including rock concerts, ice shows, the circus and an annual flower show. It was recently the kickoff site for Bruce Springsteen's national tour. The drawing power of the Centrum has helped the downtown's collection of restaurants and shops grow and thrive.

Besides the Centrum, the Worcester County Music Association brings a full schedule of classical music to the Worcester Auditorium and an International Artists Series attracts classical music stars to Mechanics Hall.

> "Less expensive than Boston, Worcester offers an easygoing lifestyle and community spirit often missing in bigger cities."

The hall, built in 1857 by the Worcester County Mechanics Association, once attracted the giants of 19th-century music, literature and politics to Worcester. By the latter half of this century, though, it had become a rundown relic, reduced to hosting wrestling matches and roller derby meets.

With the support of government, business, private citizens and Worcester schoolchildren (who gathered $9,000 in pennies to support the renovation), the hall was returned to its former glory by the late 1970s. Today, it is widely regarded as one of the finest concert halls in the country.

The Worcester Art Museum, the second largest in New England, mounts several highly praised exhibits each year, many from its own collection, considered one of the best small collections in the country. The Higgins Armory Museum, which houses one of the largest assemblages of arms and armor in the world, recently underwent a major renovation. And the Worcester Science Center was recently renamed the New England Science Center to reflect its growing influence in the region.

Worcester's colleges all offer cultural events open to the public, a switch that began in the early 1970s with the creation of the Worcester Consortium for Higher Education (see the Winter 1988 *Journal*).

Along with Worcester's burgeoning sophistication has come renewed interest in restoring much of its exceptional architecture. Buildings that once served as warehouses or factories are now home to upscale shops and restaurants. An example is One Exchange Place—a renovated police and fire station whose tenants now include restaurants such as Legal Sea Foods. In addition, older office buildings are being spruced up and restored to their former elegance.

While attention is being paid to the old Worcester, others are looking ahead to a new city skyline. Worcester's still relatively low real estate prices have attracted outside developers interested in investing in and developing local property. At least three major Boston real estate development or architectural firms are currently working on multimillion dollar projects in Worcester's downtown.

Among the most ambitious is City Plaza, a $94-million complex that will include a 26-story office tower and a 15-story condominium tower connected by a low-rise commercial area and a 600-space parking garage. The development, which will rise on vacant land near the Centrum, has been billed as a "signature" building for the new Worcester.

Plans for another major development project, a hoped-for renovation of the former Union Station into a convention center, are moving along. State funding for the project is expected to be approved soon.

Still, while several projects now crowd the drawing boards, local political and business leaders hope to see still more downtown development. Worcester has maintained its status as the second-largest city in New England, these leaders say, because it exceeds Hartford and Providence in area, not because it matches those cities developmentally.

City Manager William J. Mulford, formerly head of the Worcester Office of Planning and Community Development, agrees. He hopes the city will eventually adopt an in-the-works master plan to address the need for organized development.

One factor that could be a key to further development, say business leaders such as Paul S. Morgan, chairman of Morgan Construction Company and a member of WPI's Board of Trustees, is the expansion of Worcester's municipal airport. While its services seem limited when

New owners and a major renovation should help Worcester Center (r), also called the Galleria, become the flagship of the city's retail base.

THE GALLERIA
AT
WORCESTER CENTER
WISHES EVERYONE A
SAFE AND HAPPY HOLIDAY
FRONTIER

Worcester officials hope to see the city continue to develop, while maintaining the qualities that make it an attractive place in which to live and work.

compared to full-service fields such as Boston's Logan International Airport or Hartford's Bradley International Airport, Worcester's facility has made great strides in recent years.

Today, three major airlines, Piedmont, Continental and Northwest, serve the city, flying passengers to hubs in Baltimore, Newark and Detroit. Eastern Express offers commuter service to various destinations in New England. Passenger boardings doubled during 1987 and are expected to hit about 130,000 in 1988. The City Council recently approved a multimillion dollar package recommended by the Worcester Airport Commission that is aimed at modernizing the airport, including the construction of a new terminal building.

While development has been on the rise, Worcester, like other older cities across America, has at times been in danger of losing its downtown retail base to outlying suburban shopping malls. Worcester Center—known as the Galleria—was designed to address this issue.

The center opened in 1972 to great acclaim, but critics and supporters alike now agree it has not fully lived up to its commercial promise. Whether it is the charge for parking in the center's garage or an imperfect blend of stores, Worcester Center has been losing customers to a new group of other shopping malls built in the 1980s.

New England Development and S.R. Weiner Associates, whose combined credits include development of such successful retail centers as the Arsenal Mall in Watertown, MA, The Mall of New Hampshire in Manchester and the Pheasant Lane Mall in Nashua, NH, expect to assume ownership of the 17-year-old center by the end of the year. They plan a major renovation including, quite likely, more anchor stores and more retail space.

Where do these changes leave Worcester?

Alexander Drapos is a Worcester lawyer who has traveled around the country with the Dukakis presidential campaign. Returning from campaign trips, Drapos sees a city with a strong economy that's becoming more sophisticated—"more of a gray collar town, a mix of blue and white collar."

Many business leaders agree with that perception. They see in the new Worcester much to praise and much to look forward to. Still, some, like Charles Norton, a principal of St. James Properties, urge the city's people to keep the wheels of change moving.

Norton, whose firm has built such major Worcester development projects as Smokestack Place, a factory block on Cambridge Street which St. James converted into a successful office building, characterizes Worcester as "a city that could be better to itself."

"Worcester is at the hub of New England," he notes. "It has the opportunity, the financial strength, the lifestyle and the people to be better than it is today. To have more activity, to be a place where people want to come to and be proud of."

Worcester native Amy Zuckerman is a former reporter for Worcester's Evening Gazette. *She has written extensively about the new Worcester for Worcester-area business publications and* The Boston Globe Sunday Magazine.

Electronics in the body shop

By Marshall Ledger

Devices implanted in humans are getting smaller and smarter. The best of them might help the paralyzed to walk or the deaf to hear. But we're a long way off from a functioning Mr. (or Ms.) Chips.

Her name is Ophelia, and she is a plastic model of the human skeleton, three-fourths life-size. She is fleshed out with artificial medical parts, among them glass eyeballs, coated titanium teeth, a Jarvik artificial heart, a metal elbow, a plastic wrist, silicone finger and toe joints, bone pins, a polyurethane bladder, an electric device that stimulates bone growth, and a sensor that detects fluid pressure in the brain.

Ophelia is a fixture in an introductory course on biomaterials at Johns Hopkins University. Emanuel Horowitz, professor of materials science and engineering, co-teaches the course along with Edward Mueller of the federal Food and Drug Administration. They ask their students to obtain commercially available replacements for human parts, which the students then place on or in her.

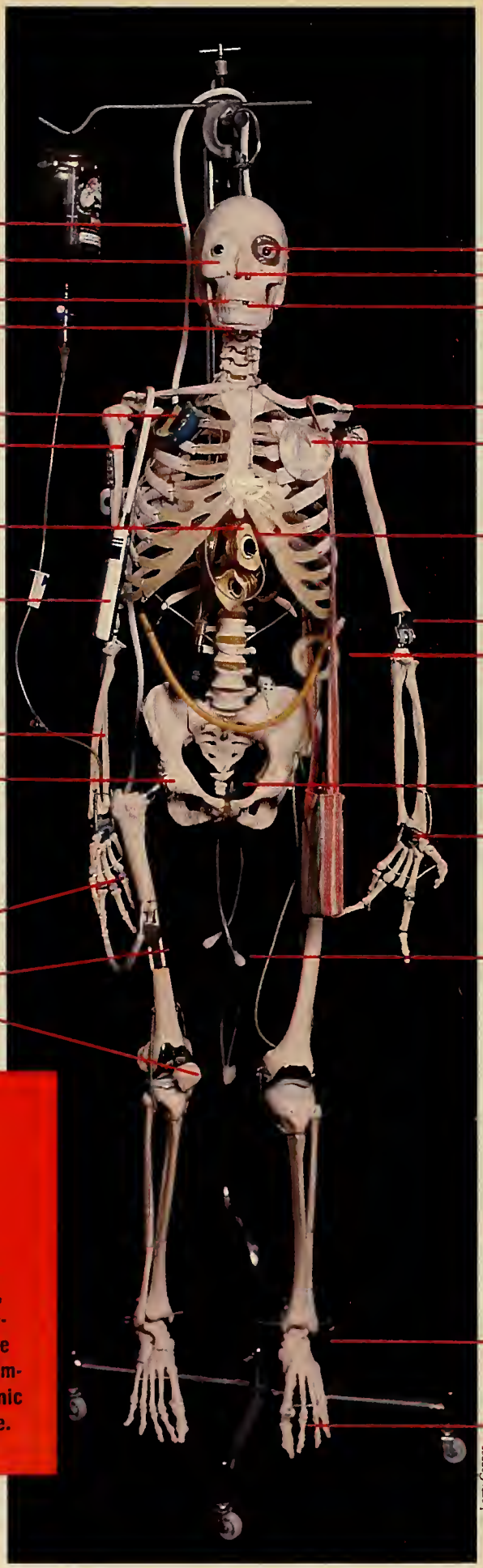
Even as an educational tool, Ophelia only hints at the state of the art of artificial devices. Most of her prostheses come, so to speak, from the body shop. They are mechanical substitutes, like new axles or carburetors; or they are nonworking stand-ins. The artificial bladder, attached to the skeleton just as the spring semester ended, is a different order of device. Along with the artificial heart and the sensor, it is implanted to help restore a deteriorating or lost bodily function. Simulating the natural organ or tissue, such parts react to the body's electrical, chemical, or physiological signals, then carry out or take control of necessary bodily processes.

Such devices represent the relentless advance of biomedical apparatuses to monitor conditions in the body, to diagnose problems, and, in some cases, actually to treat them. The substitute organs relieve both patient and physician from the anxiety of waiting for a transplant from human donors. The sensors, the latest frontier, bring about new standards of accuracy to refine therapy.

These technologies come from a world that challenges scientists and engineers to duplicate not merely the anatomy of the body but also to mimic its natural functions, playing off the body's chemistry and overcoming wear and tear.

It is a world in which bioscientists and bioengineers realize how very little they know about how the body works, much less how to imitate it, suggests Robert Peura, director of the biomedical engineering program at Worcester Polytechnic Institute (WPI). Howard Chizeck echoes that sentiment. The associate professor of systems engineering and biomedical engineering at Case Western Reserve University (CWRU) helps develop electronic devices for paraplegic people. He chafes at the hardware limitations of today's devices, yet finds "even more constraining" the lack of deep knowledge about basic body mechanics.

And it is a world of thinking small in order to think big. Microminiaturization has made possible many of these biomedical electronic marvels. Size has already advanced beyond ordinary comprehension: Scientists expect to develop electronic switches no larger than a molecule. A University of California at Berkeley research lab has produced a microphone so small a postage stamp could hold 50 of them; it bears great potential for use in hearing aids. In the not-too-distant future, Ophelia may be decked out in parts hardly visible: for example, microsensors to let doctors "see" the inside of a wound or even repair artery walls, and micromachines to be deployed to make repairs on a silicon ehip. Radios with maybe five transistors not long ago were the size of a pack or two of cigarettes. "Now we can put 10,000



Hydrocephalus shunt
Proplast facial implant
Dental (tooth) implants
Proplast chin implant
Pacemaker
Humerus metal bone plate
Artificial Heart
Bone growth stimulator
Forearm bone plate
Total hip implant
- metal alloy
- polyethylene
- acrylic bone cement

Silicone finger joint
Femoral intramedullary rod
Synthetic total knee and patella
Artificial eye
Silicone nose implant
Synthetic bone for augmentation
Total shoulder
Silicone breast implant device
Pyrolytic carbon heart valve
Synthetic elbow
Electrical stimulator for spinal cord
Foley catheter
Wrist implant
Implantable urinary sphincter
Heel bone staple
Silicone toe joint

Larry Canner

What makes Ophelia tick?

Attached to this classroom plastic skeleton are artificial human parts readily available, made from glass, metal, or synthetics. Most of Ophelia's parts are not electronic. In the future, students gathering human implants for study might find electronic switches no larger than a molecule.

transistors with 30,000 interconnecting wires on a quarter-inch square that is 20/1,000ths of an inch thick," says Robert Fischell, chief of technology transfer at Hopkins's Applied Physics Laboratory (APL).

That happens to be the size and electronic complexity of the computer chip inside a programmable implantable medication system (PIMS), an insulin pump and valve device about the size of a hockey puck. Adapted from technology developed for the Viking Mars Lander, Fischell's project is, in effect, an artificial insulin pancreas. It's designed to prevent or lessen the complications of diabetes, among them blindness, loss of limbs, and impotence.

The pump dispenses insulin to the patient on need—and it determines the need. After a physician sets the prescription via the pump's computer, which can control the flow of insulin for up to four months, it "remembers" how much insulin has been delivered, hour by hour. Computer algorithms ensure that it does not exceed the limit. "That's the type of 'thinking' it can do," notes Fischell.

The pump's machinery is called an open-loop device because it is programmed through a keyboard; a physician at a console monitors the reaction of the implant, following progress and even changing the dosage. The patient, using a hand-held device, before eating can also call up insulin in pre-programmed levels taking into account that he or she is about to munch on, for example, "a small, sweet snack."

Currently, diabetes patients must receive one to four shots of insulin a day. The pump eliminates the daily need for injections; patients check in at a hospital a few times a year to have the pump's reservoir refilled. Placed in the abdomen, the pump releases insulin near the point where the pancreas would. As Fischell puts it, "We're trying, as closely as possible, to mimic what nature did."

Of the nation's 1.5 million insulin users, however, only 16 have the implant, since development has progressed only to clinical trials. The patient using it the longest has had it for a year and a half.

Marshall Ledger is editor of Penn Medicine *at the University of Pennsylvania Medical Center. Except for a plastic patch covering a hernia, he has, so far, not required implants to keep him moving.*

In addition to regulating insulin more dependably, for the thousands of diabetics who now carry external pumps, the device will make social life more pleasant. Says Fischell, "One lady said, 'Did you ever try to wear it on an evening gown?' And teenagers don't like it because they look different. But the implant is cosmetically unnoticeable, even if you're in a swimming suit."

A trained physicist whose expertise is in building high-quality miniaturized circuits, Fischell is in APL's space department, where the goal of "technology transfer" means applying the elegant science learned in satellites to medicine, especially implants. Other projects of the lab include a rechargeable heart pacemaker, a human-tissue stimulator, an implantable heart defibrillator, and, for incontinence, an artificial urinary sphincter.

Fischell enjoys telling how the insulin pump originated. In 1976, while on vacation, he was studying the books on diabetes and insulin that he had brought along. He sketched a device, but once back home, filed away his papers. Then, two and a half years later, a medical scientist asked him about the feasibility of an insulin pump. Fischell dug up the drawings and said, "You mean a pump like this?"

He believes an implantable pump could be studied for application in neurological problems such as Parkinson's disease or spasticity. More immediately, the pump might be adapted to administer chemotherapy to a cancerous bladder.

Some devices have such immediate appeal that the public forgets the long lag between laboratory experimentation and availability. CWRU's Howard Chizeck conducts research on neural prostheses, devices that replace functions ordinarily carried out by the nervous system. He and his associates electrically stimulate muscles of patients who are paralyzed. Through their technique, called functional neuromuscular stimulation, they look for ways to enable patients to regain movement in their limbs and to control and coordinate those movements. The work is easy to relate to: If it succeeds, some people made paraplegic by spinal cord injuries (and there are an estimated 20 new patients nationwide each day) may regain some ability to walk.

Doug Garmon

Using electodes to stimulate muscles, Howard Chizeck at CWRU explores how to restore normal movement in paralyzed patients. As a patient takes a step, the computer coordinates the movements.

One of Chizeck's colleagues, P. Hunter Peckham, associate professor of biomedical engineering, has used electrical excitation to restore a few hand and forearm functions to paralyzed people. Some patients can now feed themselves and do other personal tasks. One patient has received an implanted unit driven by radio waves from the outside, but the work is in an early stage of evaluation at collaborating institutions.

The limbs of Peckham's and Chizeck's patients are stimulated by electrodes set near or into appropriate nerves. But even determining how best to do that is a challenge. Chizeck notes that electrodes on the skin surface are the easiest to install but the least selective in the muscles they activate. Insert-

1988 Janet Woodcock

Plugging electronics into medicine are WPI's Robert Peura (above) with an *in vitro* blood measurement system; Hopkins's Robert Fischell (far right) with an implantable pump; and CWRU's Yoram Rudy (right), who researches the heart's electrical activity.

Doug Garmon

ing electrodes through the skin is more difficult but enables better mobility in specific motions. And implants, though eventually probably the best choice, require surgery.

Yet such motion only approximates normal human muscles. Chizeck has stimulated only some 48 channels of muscle control. It's "a lot in terms of technology," he points out, "but crude compared to nature, compared to the original equipment," in which tens of thousands of channels are involved in moving a leg or an arm.

Most neural prostheses require an external computer to be programmed with the appropriate information. Chizeck's system uses sensors to feed back into the computer data on the movements patients are making; for instance, one foot can detect the heel of the other foot touching the floor. But such a system must be exceptionally reliable; one wrong signal could make a patient trip. Some patients have been able to walk as far as several hundred meters, but the effort is so great that perhaps only the researchers could call it progress.

There's still considerable work to be done in many areas of basic research. Stimulators applied directly to the brain indicate the nature of the problem. In one project, appropriate areas of the brains of blind people are electrically excited so that the patients visualize white flashes. Could the electrodes be fired sequentially in a way that develops images in the mind?

No one has yet advanced that far, but experiments of this type are planned for the near future. Miniaturized electrodes are now "pretty close to the smallest they can be," notes Terry Hambrecht. A 1968 Hopkins medical graduate, he's in charge of the neural prosthesis program of the National Institutes of Health, where he studies the points of contact between the electrodes and the nervous system. He is experimenting with electrodes only five microns thick, approaching the size of nerve cells (a human hair might be 100 microns thick). The electrodes float with the brain by means of a flexible wire. (The brain doesn't exactly rattle around inside the cranium, Hambrecht points out, but its movements do affect the delicate implant.)

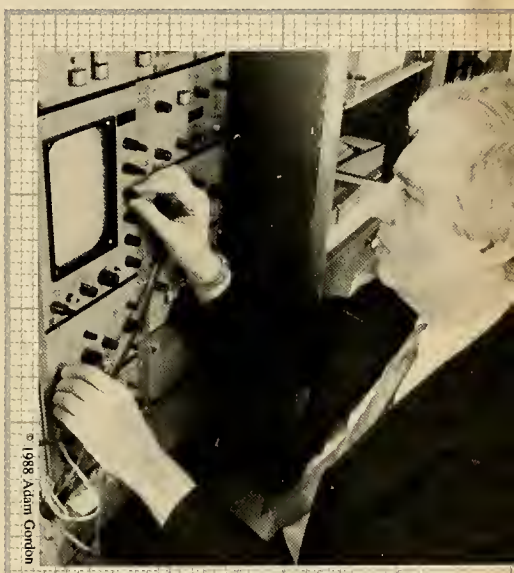
Tiny electrodes have been used in cochlear implants to restore a degree of hearing to some deaf people. Deafness is sometimes caused by a malfunctioning of the sensory hair cells of the inner ear. The implants pick up acoustic signals and, substituting for the hairs, transmit the signals to the brain as electrical impulses, which the brain accepts as "sound." In Horowitz's introductory biomaterials course at Hopkins (where Ophelia hangs out), Hambrecht has shown a videotape of a patient, deaf from the age of 12, who was given a cochlear implant. An exceptional patient, she can decipher enough words to answer the telephone. The device is still being refined, but already some 3,000 patients are using it. (See box on page VI.)

Few things are as dramatic as a new therapeutic device, but to physicians, an effective diagnostic tool can be just as welcome. Electronics are making possible less invasive techniques. Take, for example, the medical screening being studied by Edward Kresch, associate professor of electrical engineering at Villanova University. Kresch leads a team attempting to characterize injuries or diseases according to electrical signals sent out from the spinal cord or the brain. The group takes measurements at the Lafayette Hill Medical Center, not far from campus, where patients come with back problems and sports injuries, or for physical rehabilitation.

At the center, medical technicians give patients mild electric shocks on the arm or leg or elsewhere on the body (they feel no pain). In measuring the response on the skin, if the technicians find no response after a given point along the spinal column, they know the problem is at that spot. If surgery is required, the physician can pinpoint where to make the incision. The test is expensive and can run more than two hours. But compared with exploratory surgery, it's short and far less costly, Kresch notes. It's also less invasive than X-rays, whose ionizing radiation has a permanent and cumulative effect on DNA.

A computer provides Kresch with a diagram of the signals, which have a "very distinctive shape" in normal subjects but vary with different injuries, diseases, and metabolic derangements. Right now, physicians have to look at the computer screen image and decide if the signal *looks* normal. Kresch wants to quantify the signals to make it easier for them to judge how far from normal the signal is and what—if any—therapy is needed.

Kresch's team has measured dozens of normal subjects and hundreds of abnormal ones. They will continue to test groups of patients with the same disease or type of injury—for instance, some with abnormal curvature of the spine, others with muscular debilities or metabolic disorders. They expect to determine the normal range of signals (or the characteristically abnormal one) for each classification of patient. Then they would like to try predicting the problems



By measuring signals from the spinal cord or brain, Villanova's Edward Kresch attempts to characterize injuries and diseases.

of randomly chosen patients by matching their signals to those of the groups. "It's a rather crude estimate to say you can quantify a complicated thing like this with a single number," Kresch observes, "but it's a start."

Working in an entirely different field for similar diagnostic purposes, Yoram Rudy, associate professor of biomedical engineering and cardiology at CWRU, specializes in the electrical activity of the heart. Rudy seeks an understanding of cardiac electrical impulses, under both normal and abnormal conditions. His

work could lead to an understanding of rhythm disorders, which are responsible for the majority of incidents of sudden death from heart problems.

In an applied aspect of his research, he tries to develop noninvasive methods to measure electrical fields on the torso and to determine what is happening to the heart. The work is an extension of the familiar electrocardiogram, in which technicians sample the potential distribution at six or 12 selected points—"inadequately" sample, says Rudy, because having so few measurements forces the cardiologist to resort to "guesswork" to understand the electrical state of the heart.

A surgeon usually determines the focus of the arrhythmia during open-heart surgery by mapping the electrical activity directly on the heart; to do so requires wrapping electrodes in a "sock" placed on the heart. This procedure prolongs surgery and, ironically, can cause arrhythmias, says Rudy.

He is trying to develop a more thorough and noninvasive mapping system, monitoring 240 points on the skin's surface. He would then produce a color map of the potential distribution of the electrical fields on the torso (color-coded for different voltages). The map would be displayed on a TV monitor every millisecond during the cardiac cycle.

"That gives us more information, but it's not enough," he notes. He still has to interpret it, and that's a difficult mathematical problem, known as the inverse problem (in math jargon, he notes, it's dubbed an "ill condition problem," i.e., an unstable one). He works with a bank of computers at CWRU as well as through a telephone modem to the National Science Foundation supercomputer in Pittsburgh.

In the near future, he expects to test the mapping procedure on patients prior to surgery, then verify the findings during surgery—"with the hope that as we develop more and more trust in the results, we will eventually dispose of the need to do any mapping during surgery." So far, the procedure can localize electrical events on the heart with an accuracy of about one centimeter—accurate enough for surgery.

Searching for noninvasive technology, researchers turn to many scientific specialties. At WPI, engineers have perfected a technique called pulse oximetry, which uses optics to detect the amount of oxygen in the blood (as blood picks up oxygen, it turns red). WPI's team places an electro-optical sensor on top of the skin of subjects, and directs light through the skin at two wavelengths. Some light is absorbed by the blood, some is scattered into the tissue, and some is scattered back and registered by a detector. The amount of light detected is a function of how much oxygen is present in the blood, indicating how well the respiratory and circulatory systems are functioning.

Robert Peura and Yitzhak Mendelson at WPI are using a similar approach, which will measure glucose susceptibility in diabetic individuals. Peura explains the discovery process: He and his associates didn't know, at first, how to elicit the optical characteristics of glucose. It turned out that, in the band that a carbon dioxide laser puts out, the amount of light absorbed by various glucose solu-

Who will benefit? Who will pay?

Should people who need a biomedical device subject themselves to experimental science? Take, for instance, the cochlear implant, which simulates acoustic signals and restores sounds and even an understanding of speech to some otherwise deaf people. "I do not now recommend implantation," says Frank Bowe, a 1969 graduate of Western Maryland College who chaired the United States Commission on Education of the Deaf. An authority on microcomputers and an advocate for the disabled, he was the first executive director of the American Coalition of Citizens with Disabilities.

Bowe is deaf. He points out that the cochlea lies dangerously near facial nerves that could be severed by miscalculated surgery—a penalty too stiff for the current status of cochlear-implant technology. He would prefer to wait until it gets out of the Model T phase and into a stage of sophistication more like Ford's Taurus, he says.

Bowe feels that speech recognition via computer is a more fruitful line for deaf people to anticipate. Such technology currently, he says, is "speaker-dependent"; the computer makes templates from a specific speaker's words, then displays them on a screen as that speaker says them. Voice-recognition machines that function independently of a specific speaker are "about five years away." He adds, "What we are doing outside the body will get us to real comprehension of speech faster than this device implanted in the body."

But assume that a cochlear implant involved no risk. Patients would still face the recurring health-care question of access and cost. Currently a cochlear device, including surgery, costs about $20,000. Physicians can determine in advance whether a patient is physically able to receive the implant (depending on whether bone has closed off the inner ear), but they can't tell how much a patient will benefit from it before the implant.

Will insurance pay for something so uncertain? Terry Hambrecht at the National Institutes of Health is mindful of the problem, but notes, "For people in research, our main consideration is making these devices possible. Once we develop them, we go on to try to perfect them or develop new ones and hope that the rest of the system will take care of providing them to individuals."

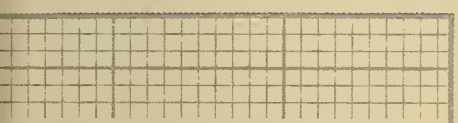
But few researchers seem comfortable about that prospect. Howard Chizeck at Case Western Reserve University notes that some devices enhance the quality of life without obviously changing the productivity of the recipients; he wonders if insurance companies will be eager to cover costs in such cases, even though the technology could cut the cost of full-time care, not to mention both the financial and emotional drains on the families.

In the United States, health-care costs already consume some 11 percent of the gross national product. New devices bring new dilemmas, if only over the cost. For example, an implantable defibrillator can sense whether blood is being pumped to the heart and within seconds send an electric shock to restart the heartbeat. It's a technological advance over the portable machine used by par-

tions changed; the more glucose, the more absorbed light. They first measured glucose and water, then glucose and blood. The researchers made use of a special prism to prevent the liquid from absorbing too much of the light energy.

One remaining challenge, Peura says, is finding a way to make the measurement without drawing a blood sample. Then it would be as noninvasive as the pulse oximeter.

For this kind of research, Peura points out, information from the sensor must be what you want to measure—yet often that's the catch, because the body's physiology changes constantly. Pulse oximetry can be thrown off, he notes, if the blood that's measured comes from a person who has just stepped in from the cold, whose body is adjusting to the warmer atmosphere. Or an electrocardiogram done on a person who is exercising might mask electrical signals given off by the heart with those generated by the active muscles. Peura seems to speak for Kresch and Rudy and many others when he says, "You can analyze data to the nth degree, but if you don't have a representative signal, it's of no value. That's why the whole area of sensors and making accurate measurements is so important."



amedics, where delays of a few minutes can cause irreversible brain damage. Long-term care for a brain-damaged patient is extremely expensive. But the implantable defibrillator costs about $15,000; tests, surgery, and recovery might run another $20,000.

In the United Kingdom, there's a two-to-three-year, government-assigned waiting list for the implantable defibrillator. Those who have the money can come to the United States and get the device and go back home. Those who don't must wait, and thus some may not live as long as they could have with the device.

Alfred Potvin devoted 17 years to university teaching before arriving at Eli Lilly & Co. to work on biomedical products. When his students questioned cost, distribution, and ethics, he let them respond to each other's points. "Invariably," he says, "I'd find that you get into a controversy that no one has an answer to—which is about where we are in the real world."

Current sensors, as crucial as they are for so many electronic machines, are relatively crude—at least for the complex demands of hearing or seeing or walking. In fact, Wen H. Ko, professor of electrical engineering and biomedical engineering at CWRU, can make the best of them sound primitive. In the broad sense, he says, a sensor can be not only a measuring device but also an "actuator," controlling the flow of electrical impulses or bodily fluids or drugs. Nobody has designed a microactuator to put in the body to determine its own commands and carry them out, he says (that would be a closed-loop system). The insulin pump at Hopkins, he points out, requires an external programmer.

Ko is trying to develop a control with many positions, which would be useful, for example, to hydrocephalic children, whose brain ventricles are too large and fill with fluid, thus compressing the brain. Current treatment involves inserting a shunt, which directs the fluid to the abdominal cavity. Relieved of excess fluid, the ventricle recovers to almost normal size. But then the drained ventricle tends to become too small, causing severe headaches. In addition, as the child grows up, the shunt may become too short, or be accidentally pulled out, or become clogged.

Physicians would like to be able to avoid these obstacles and others—for instance, the "syphon effect," which occurs when a patient who is lying down suddenly stands up. Doctors also want to narrow the shunt as the child grows up, eventually closing it entirely. Ko estimates that a third to half of all children with hydrocephalus would benefit from such a control device.

He and his associates are building a prototype sensor that will measure fluid pressure as well as body temperature and any tendency to clog. The valve, ideally one millimeter in diameter, would open to permit anywhere from a fifth of to three times the normal flow, and be self-flushing. The sensor would last at least a decade and maintain itself automatically. And the whole package—control valve and sensor electronics—would be no more than an inch square and three eighths of an inch thick, with as many as 5,000 transistors.

Such a device, he says, would continue the development of integrated circuit technology from the early pacemaker (which had perhaps four transistors), to the insulin pump, to the electrical stimulation devices. The sensor may be the next. He figures that it's one of the most internally complex electronic systems attempted—in some ways three times the complexity of the insulin pump or the implanted muscle stimulator. He predicts that the device is a year from being tested in an animal and perhaps three years from clinical trial. "Once we show it can be done, many more things will follow," he says.

Alfred Potvin has that same feeling. "Whoever develops better sensors, inside or outside the body, is going to be in a terrific position to develop whole families of new products that will make obsolete much of what's in the marketplace today," he says. A 1964 WPI graduate who went on to earn a doctorate in bioengineering, Potvin directs the medical instrument systems research at Eli Lilly & Co. (Lilly, chiefly a pharmaceutical firm, gains 13 percent of its sales from medical devices.) Potvin oversees a research unit that, last year, successfully completed work on a closed-loop drug delivery system. Currently his 18 researchers devote all their time to biosensors.

The technology for sensors has been around since the 1950s, yet there are still no commercially available chemical sensors for measuring within the body such things as the concentration of drugs. "Biocompatibility is a problem," Potvin notes. Some physical sensors—for measuring blood pressure or velocity, for example—are available, but they may work for only a few hours or a day. With many years of additional development of the sensor, the glucose levels being tested by Peura at WPI might be read by patients who are wearing the measuring device like a wristwatch.

How refined can technology become? Scientists often don't know whether the obstacle is the state of technology or their limited understanding of how the human body works. "You never know where you're going to end up," says Peura, "so you go through steps: You know where you want to be and you look at various approaches and at what others are doing. You keep refining, going back and forth (between theory and application), until it all falls together."

The day Nixon broke into the office of the dean

Courtesy Whittier College

Big man on the Whittier campus, Dick Nixon (number 23 on the "Poetlings") at Duke later tackled a transom.

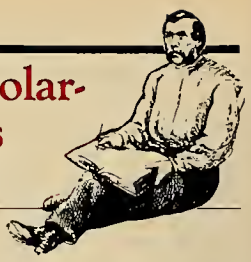
. . . and other prophetic episodes from our presidents' college careers

By Ken Sokolow

With the advent of the *Miami Herald* school of journalism, every aspect of the candidates' lives is now seen as fair game. Yet one incubator for the styles and work habits of future presidents—their college careers—still tends to be ignored, even during election years.

Since the inauguration of George Washington in 1789, 30 of the 39 men who have served as president have attended American colleges as undergraduates. And there's a striking similarity between their behavior and attitudes in college and their performance in office. What follow are some highlights (and low points) of the five behavioral types.

The Scholar-Geniuses



THESE MEN—John Adams, James Madison, and Woodrow Wilson among them—were devoted to learning for its own sake. Had they not become involved in politics, they could have become career academicians. Indeed, that's what Wilson was for most of his adult life. Scholar-Geniuses couldn't win the affection of the masses and so were respected, not loved.

Adams, unlike George Washington, his predecessor as president, did graduate from college. A man of wide-ranging intellectual curiosity, Adams became a voracious reader while a student at Harvard (1751–55). He wrote that his "love of books and fondness for study dissipated all my inclination for sports and even for the society of the ladies." But that was years before he met the brilliant Abigail Smith. The college's rigorous discipline—starting with morning prayers at 6, daily recitations, enforced curfews, and dreadful food (salt fish on Saturday was the highlight of the week)—didn't seem to affect the dedicated Adams.

Immersed in his studies, he chose not to take part in the reckless japes of his slightly younger friend John Hancock, who had been fined by the college for getting a slave drunk to the point of endangering his life. Through a literary club whose members read aloud new plays and poems, Adams developed histrionic abilities that proved to be helpful in his legal and political careers.

In 1755, one listener was so impressed with the commencement speech Adams delivered at Harvard that on the spot he offered him a job as a schoolmaster in Worcester, Massachusetts. Adams accepted and taught for a year, then began reading law. The least appreciated of the Founding Fathers, Adams as president would fight a lonely but successful battle to keep America out of a full-fledged war with France in the late 1790s.

Madison, another bookworm, was sent in 1769 to the College of New Jersey at Princeton instead of the College of William and Mary at Williamsburg, where Virginia aristocrats were supposed to be educated. His family thought the colder

climate would be more healthful than the malarial tidewater marshes. Frail and a hypochondriac, Madison studied theology, considered to be good preparation for meeting one's Maker in an untimely fashion (he lived to be *only* 84).

Madison completed the normal three-year course at Princeton in two years, but at quite a cost: His sleep, he wrote, "was reduced to less than five hours in the twenty-four." Too much study and too little exercise took a heavy toll on him for years after graduation.

Since the privately tutored youth already knew more Latin than most of his classmates, he was free to concentrate on a newer discipline—"the law of nature and of nations"—advocated by the college's president, the Rev. John Witherspoon. The educator had two basic rules for his students: "Lads, ne'er do ye speak unless ye have something to say, and when ye are done, be sure and leave off." The extremely shy Madison may have taken this too much to heart, for he never overcame his dread of public speaking. His first inaugural address, listeners complained, was inaudible.

The most recent example of the all-but-extinct species of the presidential Scholar-Genius was Woodrow Wilson. The first president to earn a PhD (from Johns Hopkins) and the first college president to become president of the United States (he led Princeton from 1902 to 1910), Wilson was a compulsive perfectionist with a marked tendency to nervous disorder. But ultimately he was an achiever. From boyhood he was imbued with the desire to become a great statesman and orator; his undergraduate hero was Gladstone, his gospel was free trade, and his attitude was that of a snobbish Anglophile.

In 1873 he entered Davidson College, but later transferred to Princeton. Even though illness forced him to leave both Davidson and the University of Virginia Law School, this self-described "idealist, with the heart of a poet" always managed to return to an academic environment.

A world-class scholar, Wilson could also be a world-class klutz. On one memorable occasion while a student, he entered an elegant Princeton drawing room, slipped on a rug, skated across a glossy floor with his arms thrown out for balance, and stopped just short of knocking over his hostess. Clearly, this eccentric genius belonged in an academic environment, where he could do

Courtesy Princeton University Library

Princeton proved idyllic for Woodrow Wilson (shown in a Vanity Fair *sketch when he became U.S. president).*

the country the least harm. By a series of flukes, he became a U.S. president, nominated on the 46th ballot.

Aloofness, reserve, and a tendency to despise popularity were common threads among Adams, Madison, and Wilson. They had enormous faith in their own judgment and rectitude, which made for tremendous difficulties in dealing with Congress. Adams lost the leadership of the Federalist party because of his stubbornness, pomposity, and political incompetence. Wilson's League of Nations proposals failed in Congress, in large measure because of his invalidism, tantrums, and contempt for back-room negotiations. For a nation to be led in wartime by men of scholarly temperament, as it was by Madison and Wilson, poses difficult problems.

Pious Plodders

THESE PRESIDENTS would be called workaholics today—or nerds or wonks by their college peers. They typically graduated at or near the head of their classes. Rutherford B. Hayes was the valedictorian at Kenyon College. Salutatorian James K. Polk took first honor in classics and mathematics at the University of North Carolina. Commencement orator Benjamin Harrison was voted "one of the three brightest men" at Miami University of Ohio. All were motivated by a deep-seated religious faith and a strong desire to succeed, all were undergraduate leaders, and all were temperance advocates. But the Pious Plodders—Jimmy Carter among them—didn't capture the public's imagination, and they were always one-term presidents.

Jim Polk, a frontier Calvinist and strict Sabbath observer, had no discernible sense of humor. Before the advent of Coach Dean Smith's basketball teams, he was Chapel Hill's main claim to fame. Polk as a student was logical and methodical. In 1818, he graduated after only two and a half years, having earned a reputation for promptness and dependability. "As certain as Polk will rise at the first call" became a campus expression for absolute certainty that outlasted his sojourn at Chapel Hill.

The campus Dialectic Society, in which Polk held every office including president, debated the question, "Would an extension of territory be an advantage

Courtesy Kenyon College

"Ruddy" Hayes roomed in Kenyon's Old Main. The college erected a flagpole around 1877 to salute him.

to the United States?" It's unclear which side Polk took, but the majority of the society voted "no." When he became the nation's president, Polk argued the affirmative—and settled the Oregon boundary dispute with the British, made Texas a state, and went to war with Mexico to fulfill America's "manifest destiny" to rule from sea to sea. Predictably, Polk as president accomplished all the goals on his agenda.

"Ruddy" Hayes became quite popular at Kenyon, graduating in 1843 and winning a reputation as a great conciliator between students from the North and the South. As president, conciliation would be his aim as well. Hayes was so morally straight that pragmatic Ohio politicians nicknamed him "Granny"; he and his First Lady, "Lemonade Lucy," banned alcoholic beverages from White House receptions.

Ben Harrison, the grandson of President William Henry Harrison, transferred to Miami of Ohio to be near his beloved Caroline Scott, whom he later married. In fact, he spent so much time on the Scotts' front porch that classmates nicknamed him "the pious moonlight dude." Like the Hayes family, the Harrisons set a high moral tone for an indifferent nation during his presidential term (1889-93). They started the tradition of the White House Christmas tree (which has lasted) and revived the Hayes habit of Sunday evening hymn-singing (which has not).

A modern-day throwback to the Pious Plodders was Jimmy Carter, who, shortly after his inauguration, lectured an audience of bureaucrats on the dangers of living in sin, urging such couples to marry. His audience at first suspected he might be joking.

Carter had been rushed through the U.S. Naval Academy in three years, due to a shortage of officers in 1946 (he also attended Georgia Tech and Georgia Southwestern College). He graduated in the top 10 percent of his class, but lamented in his autobiography that he hadn't worked up to his potential—a typical Pious Plodder attitude.

Charming Dilettantes

JOHN F. KENNEDY certainly was one. So was a lesser known and notably inconsequential president, Franklin Pierce, who was actually one of the more colorful undergraduates in American political history. At Bowdoin College (class of 1824), he had a scrape with cheating when he copied an algebraic problem from the slate of the class brain—Calvin Stowe—the future clergyman and husband of novelist Harriet Beecher. When challenged, Pierce frankly admitted his deed, delighting the class and disarming the teacher.

Pierce's charmed life at Bowdoin is an example of self-indulgence going unpunished and unchecked, and may indeed have had a lasting effect on his abilities to govern himself and his country. Thirsting for the kind of military glory his father had achieved in the Revolutionary War, Frank Pierce organized a student cadet corps that persisted in parading across the lawn of the college president. After several warnings, the president caught Pierce marching his corps across the forbidden territory. He reportedly told Pierce, "I will have you know, sir, that here civil law is superior to military." Anyone else would have been expelled, but no action was taken to punish the popular Pierce. Nor was he ever disciplined for leading a senior-year springtime rebellion and boycott of classes—rather common in 19th-century colleges with their very restrictive rules.

Nathaniel Hawthorne, a year behind Pierce at Bowdoin, wrote a flattering election-year biography portraying his college friend as one of nature's noblemen, beloved by all at Bowdoin for his generosity of spirit, his effervescent sense of humor, and so on. Pierce is the least believable character in Hawthorne's fiction, but the electorate swallowed the image.

Pierce reached his level of competence in local New Hampshire politics and a small-town law practice. But boosted by the magic of the family's name in the Granite State (where his father had been twice elected governor), he was propelled into an undeservedly successful political career. At one time, he was the youngest U.S. senator. He could be called General Pierce, without stretching the truth too far, after his service (rather undistinguished) in the Mexican War. A man with no enemies to speak of and no controversial positions to alienate the South, Pierce won the nomination on the 49th ballot at a deadlocked Democratic convention in Baltimore in 1852.

But his string of luck ran out after his election. The victory of style over substance, personality over achievement, that had sustained him at Bowdoin could not carry him through the White House. Pierce-bashing has been a favorite sport of historians for the past century. Even in his native state, a satirical Franklin Pierce Society exists "to rescue him from the obscurity he so richly deserves."

Academic Idlers

WILLIAM TECUMSEH SHERMAN said of Ulysses S. Grant, a fellow Ohioan several years behind him at West Point, "a more unpromising boy never

entered the military academy." (Sherman never met cadet Edgar Allan Poe.) At five-foot-one and 117 pounds, Grant looked more like a jockey than a future general. And it was only as a daring equestrian that Grant (class of 1843) was to distinguish himself at West Point. He set a high-jump record that stood for 25 years. He broke bad horses using infinite patience and tact, but lacked those qualities when it came to his courses.

"A military life had no charms for me, and I had not the faintest idea of staying in the army even if I should be graduated, which I did not expect," Grant wrote in his *Personal Memoirs*. "I did not take hold of my studies with avidity, in fact I rarely if ever read over a lesson the second time during my entire cadetship." He saw the Point as a place of confinement, and found his escape in reading novels, but not "those of a trashy sort," he emphasized. One of his professors, Dennis Mahan, said Grant's "mental machine was of the powerful low-pressure class which condenses its own steam and consumes its own smoke."

The two happiest days of his life, Grant later said, were the day he left West Point and the day he left the White House. Stoic and taciturn, Grant suffered through both ordeals. The pattern of academic sloppiness and escapist behavior marking his time at the military academy recurred in his two terms in the White House (1869-77). His administration was marred by unprecedented high-level graft, matched only after 1921, when the next academic idler to become president—Warren G. Harding—ushered in the era of the Teapot Dome.

Courtesy Whittier College

Nixon had hoped for Harvard, but finances kept him at Whittier.

Campus Pols

A NEW, UNWELCOME TYPE in American politics, this category harbors the shrewdest and least ethical politicians, among them Lyndon B. Johnson and Richard M. Nixon. Pragmatic rather than idealistic, they have a deserved reputation for getting things done.

LBJ, known as "Bull" Johnson for his constant exaggerations and distortions, excelled as a campus political organizer, arm-twister, and vote-getter at Southwest Texas State Teachers College.

Nixon at Whittier College was the undisputed "big man on campus": president of his freshman class, the student body, the history club, and a male social organization called the Orthogonians. He was second in his graduating class in 1934. Each year, he went out for the football team, displaying tremendous spirit and little ability. But sometimes the team let him deliver locker-room pep talks. Dick Nixon shared Vince Lombardi's credo of winning being the only thing. Unfortunately, any football team called the "Poetlings" (in honor of the college's namesake, John Greenleaf Whittier) isn't going to strike terror in the hearts of opponents.

The Whittier student newspaper, *Quaker Campus*, reported, "Nixon is a rather quiet chap about campus, but get him on a platform with a pitcher of water and a table to pound on and he will orate for hours." Some accused him of trickery as a debater; the editor of the school paper saw him pretend to read statistics from a blank piece of paper.

In his campaign for student body president, Nixon seized on an issue about which he cared little, but realized the students cared a great deal: the college's ban on dancing. He urged that students be permitted to hold dances on campus to keep them from patronizing the dives of Los Angeles. Thus he won a landslide victory—and the chore of organizing the events.

While taking charge of virtually every organization whose path he crossed, he was also getting up at 4 a.m. to buy fresh produce for the family grocery store. His family's circumstances had forced him to live at home and attend Whittier instead of Harvard, where he'd won a scholarship. At Whittier, his prudent Milhous forebears had established a scholarship trust designed to help such unfortunate descendants.

When Nixon applied to Duke Law School, Whittier President Walter Dexter wrote to the dean, "I cannot recommend him too highly because I believe that Nixon will become one of America's important, if not great, leaders." He earned a scholarship to Duke and came to lead a monastic existence to maintain the highest possible class rank. In the spring of 1936, when law students became anxious about the late posting of grades, he climbed through the narrow, open transom above the dean's office and unlocked the door for his two co-conspirators. The three friends found the key to open the desk drawer and peeked at their grades; after Nixon saw that he had dropped below third place, they put the files back and left.

Perhaps the Duke break-in did leave its mark on Nixon. If one believes a story recounted by H.R. Haldeman in *The Ends of Power*, John Dean and President Nixon were discussing the possibility of obtaining tax files on prominent Democrats. When Dean complained about the difficulties, the president supposedly responded, "There are always ways to do it. (Expletive deleted), sneak in in the middle of the night." What we see in college is generally what we get in the White House. The workers will continue to work, the shirkers to shirk, the invalids to suffer, the Machiavellians to scheme. The consequences for the nation can be quite traumatic, for example the national uproar over the "third-rate burglary" and elaborate cover-up known as Watergate.

To paraphrase the gloomy lesson of Hawthorne's *The House of The Seven Gables*, the sins of the adolescents were visited upon the adults (and the nation they led) in every generation. On the other hand, imagine how boring history would be had the nation chosen only presidents with unblemished college records. All of our leaders could have been clones of Harrison and Hayes.

Ken Sokolow studied history at Johns Hopkins. A Baltimore writer, he collects presidential anecdotes and memorabilia.

The Winners

Growth and change were the themes of our photography contest. Readers responded with more than 300 images of memorable moments. Many caught the fragility of life's beginnings: a fuzzy, newborn camel with a Mona Lisa smile; a toddler asleep in a Great Dane's paws; a sailor carrying his infant son in a matching sailor suit to the commissioning of a ship.

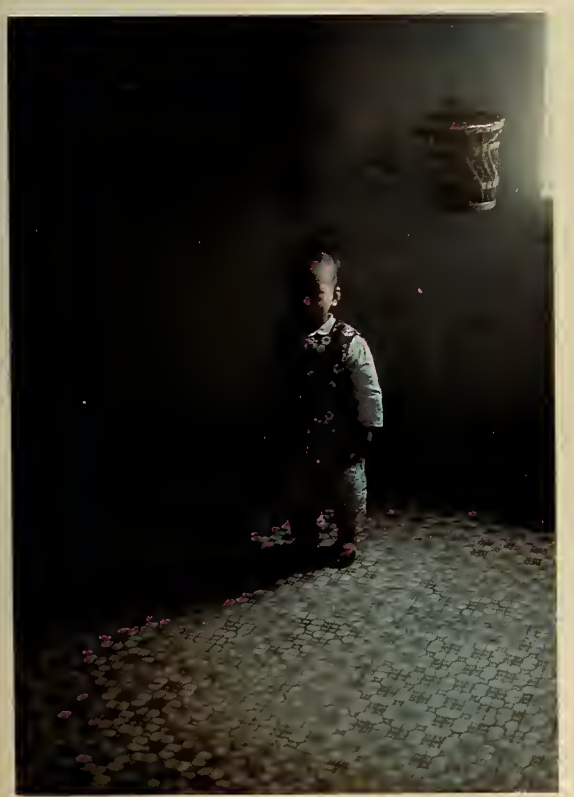
On some, the captions told a behind-the-scenes tale. One described two solemn Turkish brothers awaiting the ritual of circumcision. A nun biking through Cape May Point, New Jersey, wrote of how a row of martin houses reminded her of the "order and simple beauty in God's world."

Our judges sought out spark and spontaneity, a touch of humor and humaneness. The two grand prize winners—"Superboy" and the lava flow—are aspects of energy unleashed. They received $200; the other nine winners received $75. Our thanks to all of you who entered and to the judges: Peter Howard, a Baltimore photographer, and Amy Wells, AMC production coordinator/designer.

► First Prize, Black & White

Amalia Winer
Nepean, Ontario

This was the first time that our son had used his own imagination to create something very real to him. He made his costume, and came flying through the room. It was really fantastic!



◄ **Daniel Fred Goodman, MD**
Assistant Professor, Johns Hopkins Hospital

As I traveled through mainland China in 1982, I made many new friends. This young child, in a day-care center on a rural commune, was initially frightened by the presence of a stranger from "far away"; he ran to the far corner of this room. Soon, however, we became good friends and spent the afternoon together with the other children, playing and exploring. It was a special moment of growth for both him and me, as we were able to overcome cultural barriers and discover that a smile is truly international.

▲ First Prize, Color

John E. Bowen
Hilo, Hawaii
Western Maryland College, Class of '60

A lava flow from Kilauea volcano on the island of Hawaii enters the Pacific Ocean at dusk. To witness this sight is to feel oneself in intimate communication with nature and the forces of creation.

► **Frank P. Maloney**
Assistant Professor,
Villanova University

The physicians decided that after my wife was in labor for 46 hours, our son would need a helping hand (literally) to make the really big change to independent life. So, little Ryan Maloney was born by Caesarean section on September 9, 1987, and captured on film by his dad. Mom was . . . busy.

▲ **Barbara J. LaValley**
Groton, Connecticut
(mother of Brian W. LaValley, Worcester Polytechnic Institute, Class of '90)

Growing up brings many new experiences in life. Holding on to younger joys reminds us of those growing-up times. The sharing of father and son in this picture depicts just one of those times.

◄ Alicia Koppel
Santa Barbara, California

Two young boys by their shack in Tijuana, Mexico. Unaware of my presence (I used a telephoto lens), they were playing and learning things in their own way. It was at a time when school was in session, but, at their age, their parents prefer to keep them at home.

◄ Barry H. Penchansky, MD
Lancaster, Pennsylvania

This moment in nature was captured with the goal of offering the viewer the transcendency I experienced while taking these pictures. I was on vacation in 1983 in Upper Galilee, near the Hula Reservoir, at a bird sanctuary. I shot the reflection of the sun in a papyrus swamp. From the several rolls of pictures I took that day, this was my favorite.

► Mark M. Miller
Medical Illustrator, Johns Hopkins School of Medicine

Aging is change. Inevitable, indifferent, and universal, it is an inescapable truth of life. How we accept this change is partly determined by our own sense of self-fulfillment, and by the realization that we are really never alone.

◄ **Laura Ross Stevens**
Plainfield, New Jersey
Western Reserve College, Class of '79

While visiting the Rhode Island Children's Museum, Max stopped to paint his first picture. He turned away to play with a brush. I called for him to look toward me and as the paint dribbled down his chin, it was all I could do to take the photo.

▲ **Paul F. Viggiano**
Philadelphia, Pennsylvania
Villanova University, Class of '79

As communications coordinator for Philadelphia Life Insurance Company, I was asked to snap a few pictures at the annual Service Awards Ceremony. The final award was to be given to Rod Ross, president of the company, by Dave Erwin, the chairman. It was obvious the two men had a deep feeling for each other, and I sensed a great picture was about to happen. As the two men shook hands, Rod quickly turned and decided to plant a nice "wet one" on Dave's cheek. I snapped the picture. This moment made me realize something very important. Even in the cold, often impersonal world of business, there is always a time for love and caring. It truly was a moment of growth and change for me.

▲ **Kimberly Anson**
Frederick, Maryland
Western Maryland College, Class of '89

Sunset over Masai Mara in Kenya. Topis can be seen on the horizon at the last moment before day changes into night, and the breathtaking sunset fades quickly into darkness. How exciting it was to capture that moment!

WPI's computer-aided engineering center is helping to define the future of engineering.

The Shape of Things to Come

By Paul Susca

GONE ARE THE DAYS of the slide rule. Computers have dramatically transformed the practice of engineering, and the changes are far from over. Although such buzzwords as computer-aided design (CAD) and computer-aided manufacturing (CAM) are entrenched in the engineer's vocabulary, only recently has computer-aided engineering (CAE) come into its own. WPI's own CAE Center is less than two years old, but, with its dedicated computational and graphics facilities and pioneering research, it has quickly garnered such a reputation that last year it boasted nearly $1 million worth of industry- and government-sponsored research contracts.

"Computer-aided engineering is really a late 20th-century term used to describe what was known as mechanical design in the first half of the century," says Richard H. Gallagher, former provost and vice president for academic affairs (now president of Clarkson University), a driving force behind the formation of the CAE Center. But the work that is taking place today at the Center indicates that computer-aided engineering is much more than an extension of design activities formerly done manually by engineers with their slide

Undergraduate David Gosselin with a product of the CAE Center.

Photos by Michael Carroll

"The computer takes engineering into new territory, and changes the process whereby components and manufacturing methods are designed."

rules. CAE allows engineers to take on tasks that would be impractical and even impossible without the help of today's computers.

Much of computer-aided engineering involves the creation of mathematical models that reflect the behavior of physical systems—a skyscraper riding out an earthquake, a helicopter rotor slicing the air, a sheet of metal being run through a stamping press. In order to accurately represent all the forces at work in such systems and to take into account how each part is different from every other part, CAE models typically divide the system into segments and provide a set of equations to represent the forces at work in each segment. The finer the grain of the model—the more segments there are—the more accurately the model will represent the real-world system.

But as the model becomes more fine-grained, the task of solving all those equations simultaneously becomes massive; indeed, the point is very quickly reached where only powerful computers can perform the analysis. So the computer takes engineering into new territory, and changes the process whereby components and manufacturing methods are designed.

"Of late, computers have become powerful enough that it has become a viable approach in engineering to try to simulate the detailed response of a design in advance of actually building it," says James H. Kane, assistant professor of mechanical engineering and director of the CAE Center.

Without CAE, developing the best design would take an engineer, armed only with his own judgment, experience and gross information derived from hand calculations, through the costly, repetitive process of build and bust. Not only would the prototype part being designed have to be rebuilt repeatedly, but the tooling to manufacture the part would also go through the same cycle.

In an effort to break the build-and-bust cycle for Worcester-based Wyman-Gordon Company, a major manufacturer of parts for the aircraft industry, Kane is working with Sunil Saigal, assistant professor of mechanical engineering, to develop three-dimensional simulations of metal-forming processes on the computer. Saigal explains that Wyman-Gordon's engineers wanted to predict precisely the behavior of metals being forged into aircraft components. However, parts were sometimes ending up in a different shape than expected, even breaking during the process.

"Most of the trouble—the discrepancies between the predicted and the actual results—was on the surfaces of the parts," says Saigal. Because of the importance of surface conditions in the metal-forming problem, Saigal and Kane's approach relied on a technique called the boundary element method (BEM), which uses a mesh of points on the surface of a body rather than including both interior and surface points in the computer model. Kane and Saigal are already recognized as pioneers in the application of BEM to a different kind of CAE problem known as structural shape optimization. The Wyman-Gordon project represents an extension of the method into the optimization of manufacturing processes.

Wyman-Gordon is already using the first version of a BEM model developed by the WPI team. Anil Gupta, a Ph.D. student working with Saigal and Kane, is now concentrating on modeling metal plasticity and deformations under large strains as part of the Wyman-Gordon project. He says the first version of the model addressed only elasticity. After reducing computational time for the elasticity analysis, Gupta says the next step is to look at the much more complex large-strain responses. Gupta, who did his master's degree work at Purdue University, recently co-authored a paper with Kane and Saigal on the algorithm used in the Wyman-Gordon project.

Many of the papers that have come out of the CAE Center in its short lifetime

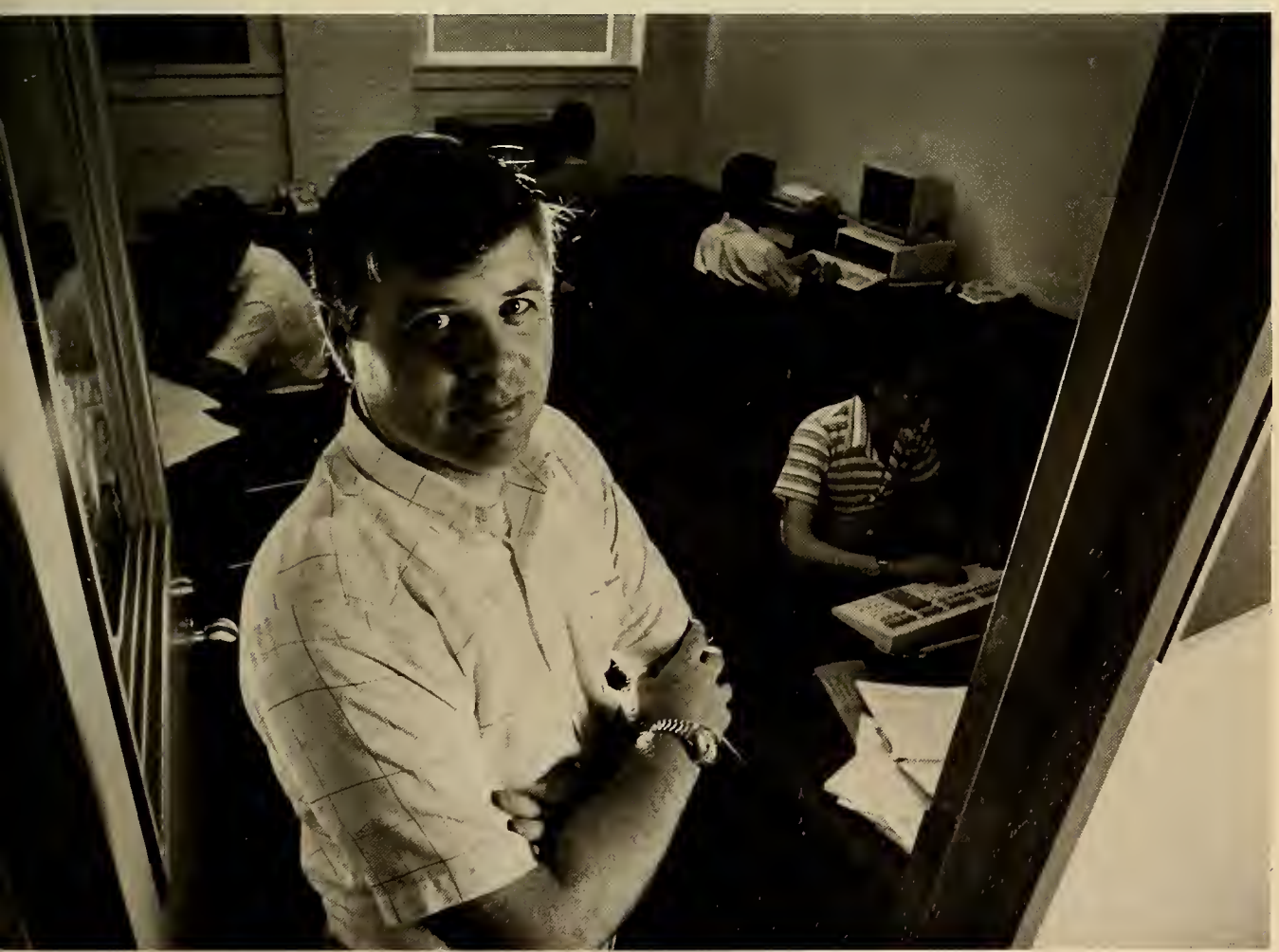
tout the advantages of the boundary element method over a better-known, more established technique called the finite element method. Finite element techniques first emerged in the 1950s—the early days of CAE—and helped make possible the design of supersonic aircraft. They reached maturity by the late 1970s, Saigal says.

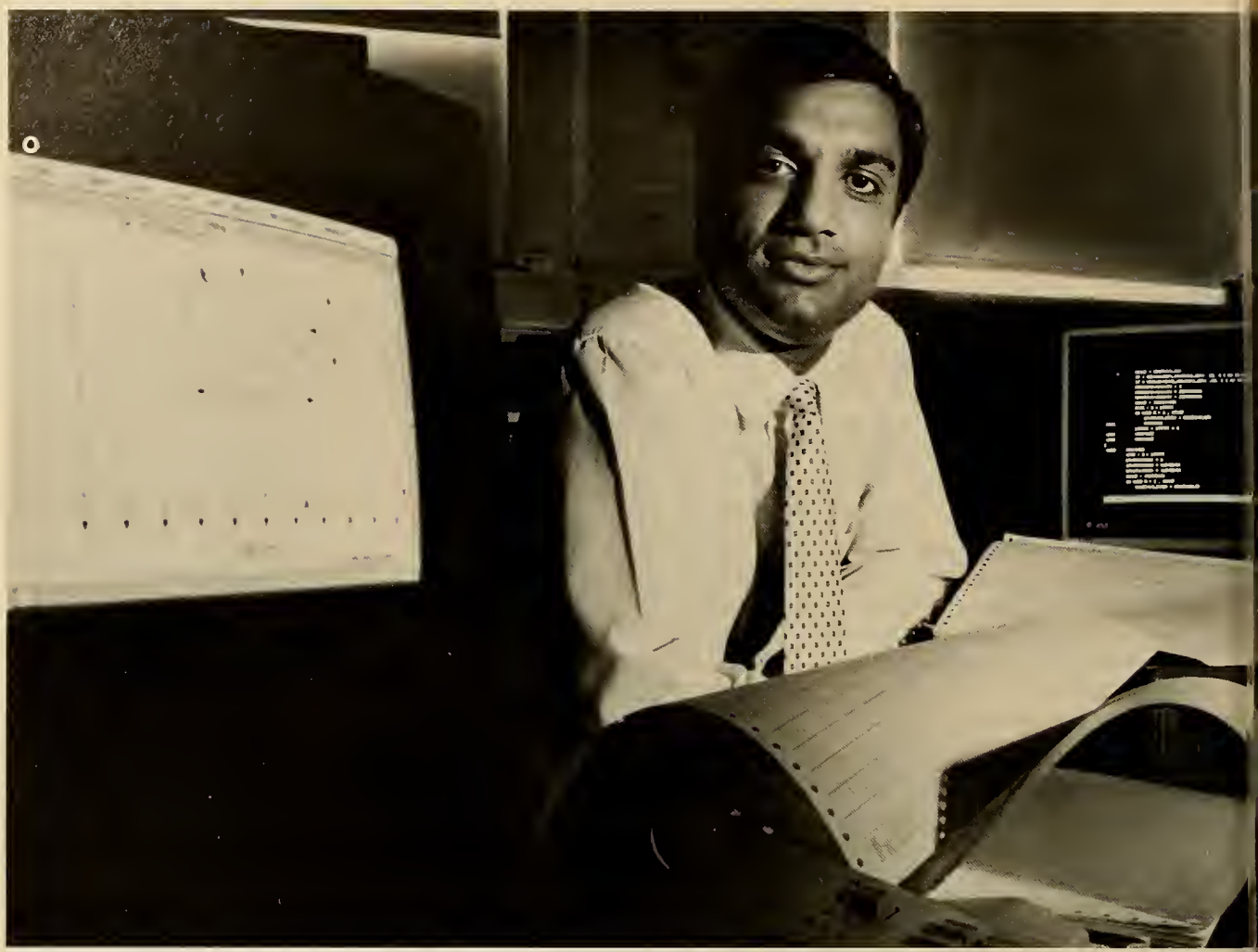
In fact, both Kane's previous consulting activities and Saigal's thesis work relied heavily on finite element techniques. Even now, Saigal is working with Isa Bar-On, assistant professor of mechanical engineering, and graduate student Benjamin Hantz in an effort to model stresses in ceramic test specimens using finite element techniques. Bar-On's project, supported by the GTE Laboratories in Waltham, MA, is ultimately aimed at developing new fracture tests for structural ceramics.

"That's pretty tricky, because these materials are very brittle," Bar-On says. "We want to see how they break. But it's not just how to break a ceramic, but how to break it in a controlled way." Her project is driven by a need to understand the fracture and fatigue behavior of ceramic engine parts.

Although Kane and Saigal continue to work with finite element techniques,

CAE Center Director James H. Kane says the close-knit atmosphere in the research collaborative promotes a sense of excitement among the faculty and students.





Sunil Saigal, assistant professor of mechanical engineering, is helping to streamline the process of designing complex mechanical parts with a technique known as the boundary element analysis.

their work on shape optimization problems has led them to prefer boundary element techniques over the finite element method for that problem. Because of its tremendous computation requirements, shape optimization favors BEM, Saigal says, because of the method's more efficient use of computer time.

The typical shape optimization problem could involve a component of a high-performance engine that subjects the part to extreme temperature, pressure or mechanical stress. Redesigning the part by altering its shape will result in a different distribution of stresses through the part, ultimately prolonging its lifetime.

"For parts which are complex," Saigal says, "you may end up with such an involved finite element model that it's practically impossible to run because it exceeds the limits of the computer."

But in order to optimize the shape of the part, the model has to be run five or six or even more times, incrementally changing the shape each time. "What you want to do in such a case is to have an analysis tool that doesn't require so much computer time," Saigal says. The boundary element method offers an answer.

Due to the importance of increased computational efficiency and to their success in formulating shape optimization approaches based on BEM, Kane and Saigal have been awarded a grant from the National Science Foundation (NSF) to further develop boundary element methods. In the early phase of the NSF work—dealing with two-dimensional shape optimization—the professors are making great strides. "We have already developed some methods where we have gone an order of magnitude lower in computational time" compared with commercially available shape-optimization computer programs, Saigal says.

Another NSF project, awarded to Saigal as a prestigious NSF Research Initiation Grant, involves the development of three-dimensional shape optimization

Isa Bar-On, assistant professor of mechanical engineering, and graduate student Benjamin Hantz are using the finite element method to study fracturing in ceramics.

methods. Again, the aim is to reduce the size of the model—the Saigal-Kane approach is to concentrate on that portion of a body that can be redesigned. Some portions of a machine part, Kane explains, must remain a certain shape in order to fit with other parts or for other technical reasons, and those portions don't have to be included in the model in their fully expanded form. "We think this approach is going to make three-dimensional shape optimization feasible with today's computers," he says, whereas today optimization is out of reach on all but the fastest supercomputers. Kane and Saigal's immediate goal is to prove that their approach can condense the model.

If Kane and Saigal seem to be carrying a heavy load of research projects, it is only possible because of the dozen undergraduate and graduate students who have become dedicated partners in the CAE Center. For example, in his thesis, graduate student Mark Stabinsky is developing efficient computer algorithms to predict the sensitivity of designs subject to various body forces—centrifugal and gravitational forces as well as thermal loading—to changes in design, all using boundary element techniques. The project is funded by United Technologies Corporation and the Electric Boat Division of General Dynamics. When Stabinsky originally came to WPI from the College of the Holy Cross, he was using computers housed in Higgins Laboratories, but he finds the think-tank atmosphere of the CAE Center's dedicated computer laboratory makes a big difference.

Creating that close-knit atmosphere was deliberately planned into the Center, Kane says. "Finding a place to house the students so that they were just a phone call away from the professors and from each other, and having a laboratory where they could work together instead of having them distributed over some terminals somewhere, makes a tremendous difference," he says, "and I think the funding agencies sense it when they come here, meet our students and see our laboratory and the publications we've produced."

The success of the Center results from more than its excellent facilities on the third floor of Washburn Shops. The Center's annual lecture series, organized by Saigal, also has a role in attracting the attention of leading CAE researchers from around the world, thanks in no small part to Dick Gallagher's renown as an early pioneer of finite element techniques for computer-aided engineering.

Kane also attributes the Center's prodigious productivity to the spirit that is cultivated by both teamwork and long hours. "It's not uncommon for there to be four or five students here on Sunday evening at ten or eleven o'clock," he says. "All of this comes together to give the students a feeling they're involved in a project that's bigger than themselves," Kane says. "I think there is something about teamwork that will embolden peo-

"As computers and computational methods advance, so does the complexity of the problems to which CAE is applied."

ple to strive beyond what they would if they were working in isolation."

One aspect of the cross-pollination of ideas at the Center is the development of computer tools that enhance the CAE design process. For example, Saigal cites computer graphics as an important tool in shape optimization work. "Graphics is not only a means of visualizing what your solution is. Your answers could be wrong and you could work on your formulation forever, but what is wrong is your input," he says.

Saigal tells the story of a grad student at the Center who worked for months on a design problem, but repeatedly obtained wrong answers on one part of the problem. Poring over the printouts didn't turn up the cause, but once the design was displayed using a graphics program developed by computer science major David Gosselin '89, the grad student's error became obvious: he had left out a routine step in the computation.

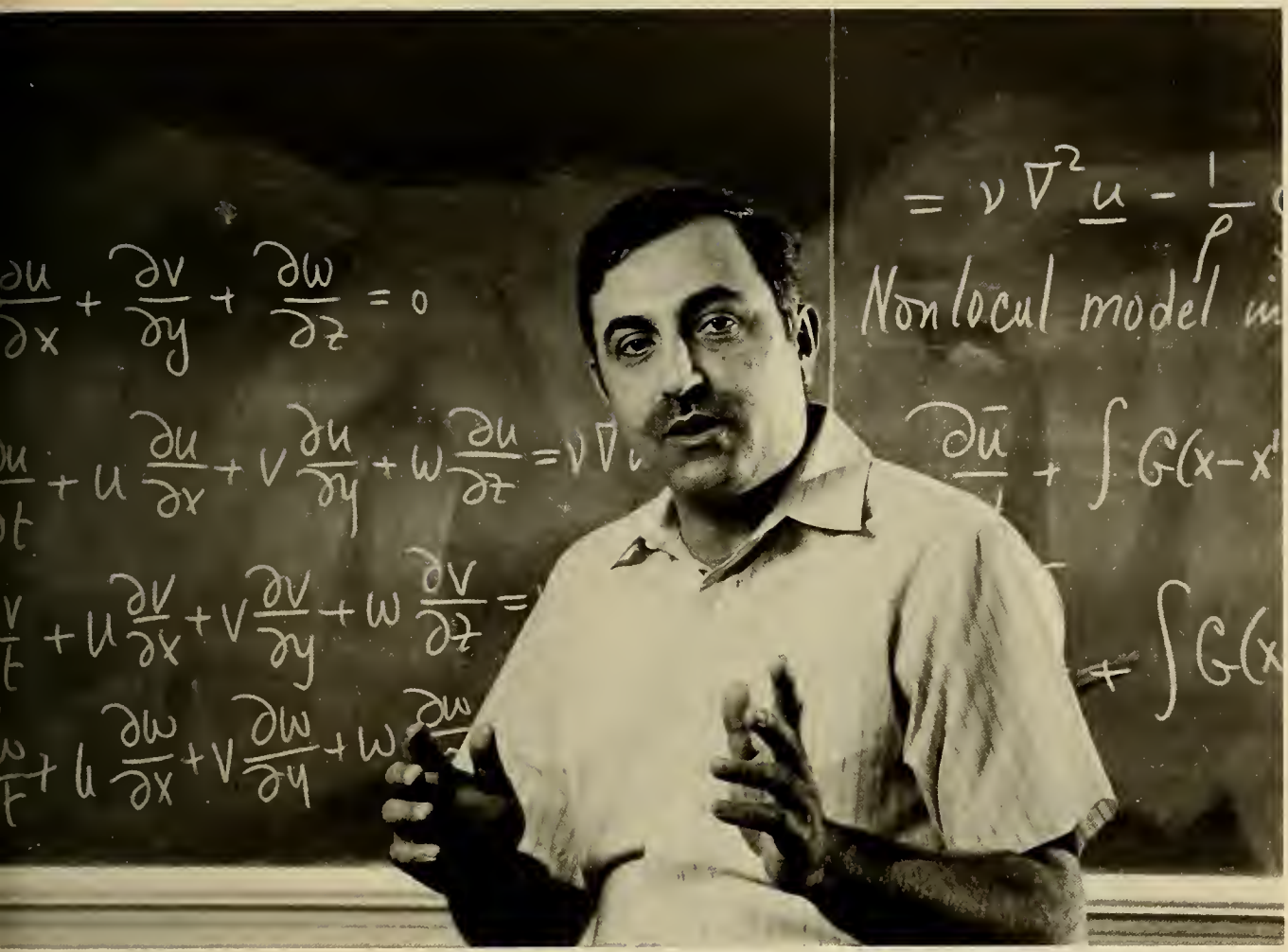
Kane emphasizes the importance of computer graphics as an integral part of computer-aided engineering. The usefulness of computer solutions would be limited without the ability to see the results graphically, he says. A graphics program being developed by mechanical engineering major Nicholas Soter '88, for example, will show temperature and strain contours drawn on the surface of a part. This will allow a designer, working interactively with the computer, to "sculpt" temperature distributions that have the required degree of smoothness.

"Without graphics," Kane says, "you could show a box full of numbers to a manager and he'd be skeptical about what they mean. But if you show him a color contour of the response of a part, right away he sees how the design needs to be changed. Engineers, especially engineers in upper management, are quite visually oriented."

The effort to develop new CAE tools is already taking the Center beyond its original concentration in shape optimization. Doctoral student Robert Dees, who came to WPI last fall because of the Center's concentration in boundary element analysis, will be focusing on underwater acoustics analysis using BEM. Dees's work, which is motivated by submarine sensing applications, will use finite element techniques to model ships and boundary element techniques to model the water. A mechanical engineer at the Naval Underwater Systems Center in New London, CT, Dees says the capabilities of WPI's CAE Center—primarily the expertise of the faculty—complement those of NUSC, particularly a Cray supercomputer that can handle problems that can't be run on the CAEC's Ridge computer.

Among the faculty that Dees cites as providing special expertise relevant to his work is Professor of Mathematical Sciences Mayer Humi, whose work has included the turbulence interactions between large structures, such as ships, and the fluids that surround them. One of the daunting aspects of turbulence problems, Humi says, is their complexity as measured by their degrees of freedom—the number of variables involved. "The area of turbulence is really very broad and very complex," Humi says. "We don't have a very good understanding of it yet. I'm working on both the practical side of this problem and on the more fundamental level." Part of Humi's turbulence work is funded by the Air Force, which is particularly interested in so-called clear air turbulence—a set of phenomena that include wind shear, which has caused a number of sudden plane crashes.

The practical engineering side of Humi's research is that "turbulence has an effect on all kinds of engineering problems," he says. "It might have an effect on the design of airplanes if it were better understood." On the fundamental level, the study of chaos, one of the trendy new areas of applied mathematics, may prove useful in Humi's turbulence work. "Chaos came along after people discovered that some dynamic



systems with finite degrees of freedom have behaviors that are somewhat similar to turbulence behavior," he explains. "So there is hope that studying the seemingly chaotic behavior of relatively simple systems will shed light on turbulence, which has an infinitely larger number of degrees of freedom. The hope is that perhaps turbulence can also be understood by a finite degrees of freedom model," Humi says.

Humi is one of several CAE researchers at WPI who are only loosely associated with the Center, but who nevertheless have a role in building the Institute's CAE reputation. Their work is helping computer-aided engineering "trickle down," in Professor Kane's words, from the design of high-performance parts to all types of manufactured items and to a variety of other engineering and scientific problems. And as computers and computational methods advance, so does the complexity of the problems to which CAE is applied.

"Technologies generally go in such a way that the easy problems are solved first," Kane says. "One looks at the stress in a component of a structure. It's a linear problem; it's solvable. And then one looks at the forging of that same component, involving large strains, plastic behavior, contact, friction, heat transfer and perhaps even solidification. It's a natural progression to more ambitious problems. We're also waiting for the next generation of computers to do these simulations."

With those computers and with the evolving tools of CAE, future generations of engineers may be able to simulate even the most complex physical phenomena with a high degree of fidelity, Kane says.

"In time," he notes, "computer-aided engineering, like the microscope, will become an integral and pervasive tool of science, and one with profound practical utility in the mainstream of engineering."

Paul Susca lives in Rindge, NH. His articles on science and technology appear frequently in the Journal.

Mayer Humi, professor of mathematical sciences, studies the complex world of turbulence to look for clues to the cause of wind shear and other phenomena.

The Myth of High-Priced Higher Education

By Jon C. Strauss

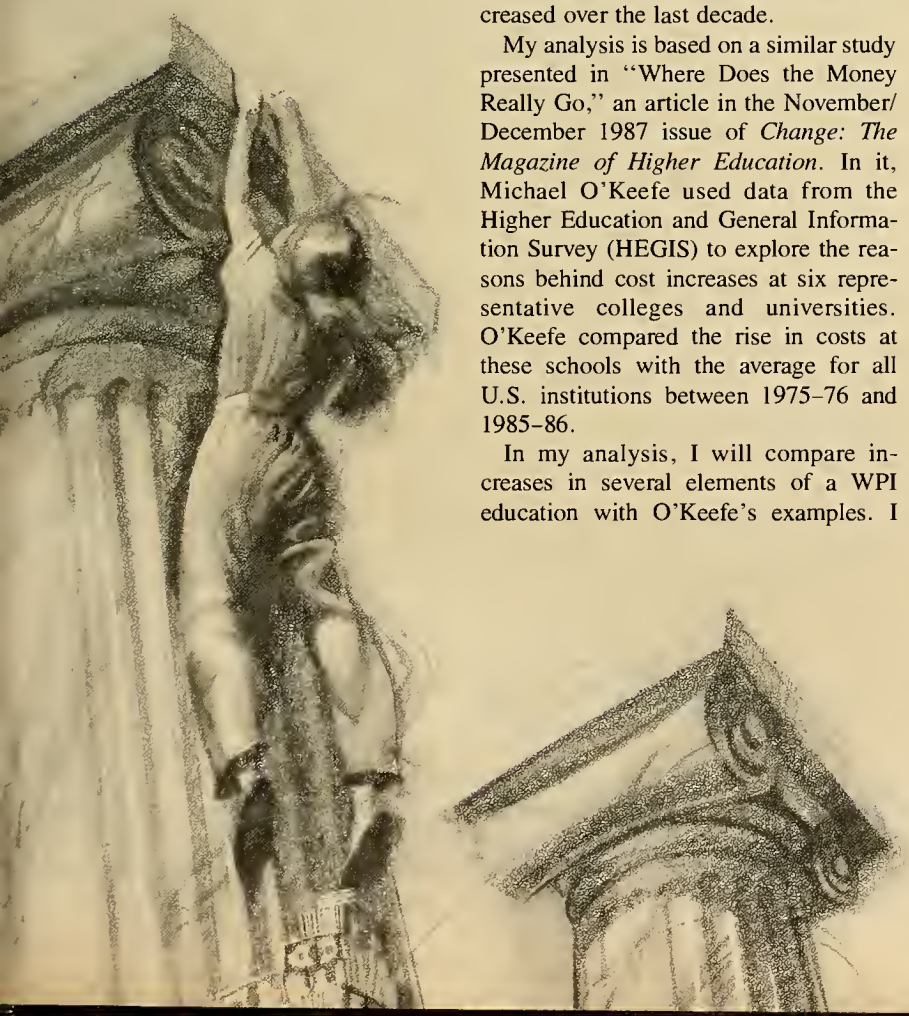
During the past two years, Secretary of Education William J. Bennett led a highly publicized attack on the apparent lack of cost controls in higher education—particularly in private higher education. With tuition at many institutions, including WPI, rising more rapidly than inflation, it may seem easy to accept Bennett's assertions.

The facts, however, don't support Bennett's viewpoint. When one looks at the cost increases at many colleges and universities over the past decade, it is clear that these increases have been aimed primarily at improving the quality of and the access to higher education. Particularly at WPI, the contribution of overhead—institutional support, operations and maintenance—to these increases has been less significant.

This is a premise that I will expand on in the pages that follow. I will look at the various expenses that add up to the cost of a WPI education and then examine how, and why, these costs have increased over the last decade.

My analysis is based on a similar study presented in "Where Does the Money Really Go," an article in the November/December 1987 issue of *Change: The Magazine of Higher Education*. In it, Michael O'Keefe used data from the Higher Education and General Information Survey (HEGIS) to explore the reasons behind cost increases at six representative colleges and universities. O'Keefe compared the rise in costs at these schools with the average for all U.S. institutions between 1975–76 and 1985–86.

In my analysis, I will compare increases in several elements of a WPI education with O'Keefe's examples. I believe you will find the figures reassuring. They show that WPI's expenditures are not only consistent with its stated mission and goals, but are comparable with those of other colleges. They also show that WPI's efforts at cost control are noteworthy when compared to the efforts of other institutions.



SALLY WREN COMPORT

Cost vs. Price

For most students, the price and cost of a college education are not the same. "Price" is the total of tuition and fees. Most colleges and universities discount this price significantly with financial aid in order to open their doors to larger and more diverse student bodies. Even without financial aid, though, tuition and fees rarely cover the true cost of providing a student an education at most institutions.

At private colleges and universities, the difference between cost and price is made up from endowment, gift, research and public service income. These subsidies typically range from 10 to 50 percent of the true cost. Public institutions also have state subsidies that reduce price even further below cost.

A simple working definition of the real per-student cost of a higher education is the total amount an institution spends for academic and support services, not including student residence and dining programs, divided by the total number of students. This approach, however, does not take into account differences in the intensity of various academic programs. For example, lecture-oriented programs in the liberal arts are inherently less expensive than laboratory-intensive programs in the sciences and engineering. This difference must be considered when comparing institutions with different missions and programs.

TABLE 1
Changes in the Components of Per Student Education and General Expenditures
Institutions of Higher Education by Type
(Constant 1976$)

	Universities*					Other Four Year*				
	1975–76		1985–86		Increase	1975–76		1985–86		Increase
	$	%	$	%		$	%	$	%	
Instruction	2,143	39	2,741	38	28%	1,561	44	1,824	41	17%
Research and Public Service	1,388	25	1,841	25	33%	313	9	522	12	67%
Academic Support	448	8	656	9	46%	292	8	389	9	33%
Student Services	189	3	268	4	41%	219	6	300	6	37%
Institutional Support	467	9	616	9	32%	508	14	629	14	24%
Operations and Maintenance	479	9	627	9	32%	395	11	466	10	18%
Scholarships and Fellowships	296	6	383	5	29%	216	6	290	6	34%
Mandatory Transfers	67	1	90	1	34%	75	2	84	2	12%
TOTALS	**$5,477**	**100%**	**$7,222**	**100%**	**32%**	**$3,579**	**100%**	**$4,504**	**100%**	**26%**

HEGIS Data from November/December 1987 *Change* article.

*The data in Tables 1–3 have been normalized to a per student basis to adjust for changes in enrollment both between institutions and with time. In addition, the dollar data for 1985–86 has been adjusted to 1975–76 dollars by dividing by the CPI inflator of 1.93 for that 10-year period. One can argue that certain institutional expenses are not linear with enrollment and that the CPI may not be the appropriate index for higher education expenses, but these normalizations provide a starting point for comparisons.

Where Does WPI Stand?

In Table 1, I have reproduced data from the *Change* article which shows the per student educational and general (E&G) expenditures for all universities and other four-year institutions between 1975–76 and 1985–86. During the 10-year period shown, E&G expenditures increased 32 percent more than inflation at universities and 26 percent more at other four-year institutions. Table 2 presents similar data for WPI and Williams College, a private liberal arts institution located in Williamstown, MA.

The tables raise some interesting points. Expenditures for instruction currently account for 43 percent of the cost of a WPI education. This cost increased 42 percent over the 10 years shown and is significantly higher, represents a bigger share of the total educational costs, and has increased more rapidly than at other universities and four-year colleges. This, I believe, is consistent with WPI's mission to provide innovative, superior instruction.

WPI allots a smaller portion of its expenditures for academic support than other universities. As we continue to computerize the campus and install a new telecommunications system, this component will likely rise to a level comparable to other institutions.

Expenditures for institutional support at WPI account for only nine percent of our total E&G costs. While this expense component grew more than 44 percent between 1975–76 and 1985–86, it is low, both absolutely and relatively, compared with what other colleges spend. As we improve administrative services and administrative information systems, this component will increase toward institutional averages.

Only eight percent of our E&G expenses are for operations and maintenance. This expense grew just seven percent more than inflation over the 10 years shown. This reflects good management practices that have been in place at WPI for some time. They are particularly impressive in light of our harsh New England winters and the excellent condition of the campus.

We spend much more than other institutions for scholarships and fellowships. With a growth rate of 110 percent over inflation for the 10 years, this expense has risen much faster at WPI than elsewhere. These numbers reflect WPI's new commitment to meeting the full financial need of all academically qualified students, as well as the higher than average price of WPI. Interestingly, not only does WPI spend more than average on financial aid, it also spends far more than Williams College, one of the best endowed and most expensive private colleges in the nation.

Tables 1 and 2 also show that WPI manages to present its high-quality technological education, with the attendant high costs for laboratories and personalized instruction, at a total cost per student that is three percent less than the average for all universities in the U.S. Moreover, the greatest cost increases at WPI have been due to increased spending for instruction, scholarships and fellowships, the components that most affect educational quality and are of greatest benefit to individual students.

Comparative Prices

Table 3 compares both the size and price of Williams College and WPI. Note that the number of full-time equivalent students and faculty at WPI were increased by exactly the same proportion over the period shown, maintaining the student/faculty ratio at a constant 15.6. At the same time, Williams reduced its ratio, no doubt contributing to the large increase in its E&G expenditures.

Both Williams and WPI experienced significant increases in tuition and fees during the period shown. Due to its larger endowment, the ratio of tuition and fees to E&G expenditures at Williams—an indication of how much of the

TABLE 2
Changes in the Components of Per Student Education and General Expenditures
Williams and WPI
(Constant 1976$)

	Williams College*					WPI†				
	1975–76		1985–86		Increase	1975–76		1985–86		Increase
	$	%	$	%		$	%	$	%	
Instruction	2,726	44	3,804	41	40%	2,110	39	2,996	43	42%
Research and Public Service	0	0	0	0	0%	969	18	673	10	−31%
Academic Support	1,072	17	588	6	−45%	389	7	429	6	10%
Student Services	492	8	1,006	11	104%	246	5	339	5	37%
Institutional Support	439	7	1,686	18	284%	444	8	638	9	44%
Operations and Maintenance	727	12	1,047	11	44%	536	10	576	8	7%
Scholarships and Fellowships	661	11	1,038	11	57%	629	12	1,324	19	110%
Mandatory Transfers	57	1	169	2	196%	32	1	21	0	−35%
TOTALS	**$6,174**	**100%**	**$9,338**	**100%**	**51%**	**$5,355**	**100%**	**$6,996**	**100%**	**31%**

*Inferred from summary data presented in November/December 1987 *Change* article.
†HEGIS data adjusted to reflect proper attribution of costs of benefits, academic computing and endowment management.

true cost of an education is covered by tuition—is lower than at WPI, even though Williams has a higher tuition. At smaller, less well-endowed liberal arts institutions, this ratio can reach or exceed 90 percent. At public institutions, with their significant state subsidies, this ratio is often less than 20 percent. While various institutions may meet their expenses in different ways, it is important to understand that the underlying cost structures of all these institutions is remarkably similar. Thus the "high cost" of private institutions is a myth.

The Bottom Line

Between 1975–76 and 1985–86, average annual increases in E&G expenditures exceeded the Consumer Price Index by less than three percentage points at the institutions shown in the three tables. Allowing for the different "market basket" and for the program improvements required to maintain a people-based organization not subject to productivity improvements, three percent over the index is not unreasonable. Interestingly, these E&G expenditure data alone suggest that higher education costs are hardly out of control, as has been alleged. They may, in fact, be one of the better controlled costs in our society.

Increases in tuition prices in the private sector have been outpacing rises in total per-student E&G expenditures. At WPI, for example, tuition and fees increased 45 percent more than inflation between 1975–76 and 1985–86, while E&G expenses rose only 31 percent. This average annual increase of some four percent in excess of the rise in the index does not reflect a conspiracy to "charge what the market will bear," but rather a need to cover the cost of maintaining and enhancing quality. Some of these costs had previously been borne by other income sources.

It is also reassuring to note that WPI's tuition and fees, while high relative to those of even many private comprehensive universities and liberal arts colleges, have been kept near the median rank of the 16 members of the Association of Independent Technological Universities. This restraint has been maintained despite the acknowledged high cost of the WPI Plan and an aggressive program of investment to improve faculty scholarship and overall program quality at WPI.

Jon C. Strauss is president of WPI.

TABLE 3
Comparative Size and Price
Williams and WPI

	Williams College			WPI		
	1975–76	1985–86	Increase	1975–76	1985–86	Increase
FTE Students	1,900	1,950	3%	2,558	3,248	27%
FTE Faculty	150	182	21%	164	208	27%
Student/Faculty Ratio	12.7	10.7	−16%	15.6	15.6	0
Tuition & Fees (T&F) (1976$)	$3,360	$5,258	56%	$3,230	$4,667	45%
Ratio T&F/E&G	54%	56%		60%	67%	

The Entrepreneurial Spirit

Ninth in a Series

Software Solutions

No model student, Ron Howard turns skill, dedication and uncompromising values into a model of success

By Michael W. Dorsey

In the spring of 1974, as Ronald A. Howard '77 completed his first year at WPI, the college's faculty and administrators may have been excused if they wondered whether he would ever amount to anything. They may, in fact, have wondered if he would ever graduate.

"Oh, there is no doubt about it," Howard says today. "I was not a model student. The first year I passed only one course, so I was not too terrific. I spent the other three years making up for that."

But, somewhere along the way, Ron Howard discovered the digital computer and his life was changed immeasurably. In the decade since he received his B.S. in computer science from WPI, Howard has turned his love affair with the computer into a highly successful software business, Datability Software Systems. Today, his company employs more than 100 people who create and market a line of innovative software products that are tearing down the barricades that once separated personal computers and mainframes.

Howard's success as a programmer began when he was still an undergraduate. When not concentrating on class work, he spent countless hours at WPI's computer center creating programs for class assignments and his own enjoyment. One of his early creations was a computer game based on the television series "Star Trek." The game was an instant hit on campus. Even today, versions continue to turn up on computer systems around the country.

For his Major Qualifying Project, Howard wrote a new compiler for the BASIC programming language. (A compiler translates the language into a code that the computer can then implement.) It was an elegant package that had many advantages over similar products then available. With a $5,000 graduation present from his father, Howard decided to put his compiler on the market.

Working out of his apartment near the WPI campus, Howard made the rounds of local companies that had computers capable of using his software. But he began to see that "the world wasn't waiting for a better BASIC compiler."

"So," he says, "I ran out of money pretty quickly. I called home and said, 'Dad, I am working real hard, but I need more money.' He said, 'Well, come back to New York where I can help guide you.' Then I said, 'But Dad, my friends are up here and this is where I want to work.' His reply was, 'Have a good life.' So I packed up everything and moved back to New York, where I was born."

With help from his father, a successful entrepreneur in advertising and manufacturing, Howard began shaping his career in the computer field. It wasn't exactly instant success, Howard says, as he "stumbled for a few years" learning the ins and outs of the computer and data processing field.

"The truth is, when you start off, you need to get kicked around a little bit before you learn some of these lessons," he says. "I guess I was lucky to have had people around me who were willing to teach me. They would say, 'You don't know what you are talking about here,' and that was what I needed to discover."

Without a viable product to market, Howard began to provide consulting services for some of the largest banks in New York. It proved to be a surprisingly lucrative pursuit.

"I was getting $25 an hour," he remembers, "and I was on top of the world, because what they were asking me to do seemed so simple. I felt like I was robbing them."

Consulting for large firms that owned their own mainframe computers provided Howard with another, perhaps more valuable, benefit. As partial payment for his time, Howard was given access to the large machines for his own use, so he began work on new software ideas.

"Pretty soon, this barter arrangement was getting out of hand because I was

Ronald A. Howard '77, president of Datability Software Systems.

using $30,000 to $40,000 a month in computer time and doing far less consulting," Howard says. "I knew that one day the bank was going to realize this. So I scraped and borrowed and bought my first computer."

With a mainframe of his own, Howard was able to finance his software development work by charging other firms for time-sharing services. But unlike other time-sharing companies, which simply rent their computers to others, Howard decided to offer his clients a full range of computer services, from software development to data processing.

"Ours was a specialty business," Howard notes. "We were so dedicated to the success of our clients, whatever function we were performing for them, that it was as if they owned us—as if we worked for them."

By working around-the-clock to meet deadlines and taking on jobs that in-house programming staffs wouldn't touch, Howard and his company became indispensable to several large businesses. But success had its price. Soon, the mainframe was so tied up with time-sharing jobs that no computing power was left for development work. The solution was to upgrade to a larger system.

With ample computing resources once again, the focus of the company—by now christened Datability Software Systems—began to change. While he was happy with the success of his computer services, Howard says he was anxious to get back to writing software.

Along with Richard L. Rupp '78, a fellow computer science major whom Howard brought on board as vice president of Research and Development, he began work on what would become Datability's first major product: Control, an information management system. Control made existing database management products easier to use by allowing a manager to custom design a database, right on the computer screen, in a matter of minutes.

"It did this so completely, so seamlessly," Howard says. "It was an incredible tool. We sold tons of it. That is what got us to the next level."

The "next level" was a breakthrough by the name of RAF, short for Remote Access Facility. What Control had done for database management, RAF did for communication between personal computers and mainframes.

Until RAF came along, the way one usually made a PC talk to a mainframe computer was to turn the PC into a "dumb" terminal. Unfortunately, this generally meant that one could not take advantage of all the PC's power and versatility while it was linked to the big computer.

RAF was a revolutionary solution to this problem. It created a transparent, interactive link between the PC and the mainframe and let the PC user create, manipulate and print mainframe files (and transfer data back and forth between the PC and mainframe), just as if the mainframe was one of the PC's disk drives.

RAF was an overwhelming success. Another software company might have stopped there and rested on its laurels for a while, but Howard, Rupp and Datability began work on a new product. Called File Access Control Software or FACS, it constituted an entirely new category of software, Howard says.

"It's like word processing or a spreadsheet product," he explains. "Once people see it, the concept is so clear they can't do without it."

FACS organizes and controls central files in a large word processing, data management or accounting installation in which many personal computers are linked to a central computer.

Like a software policeman, FACS sits on top of a computer network, recording who creates and edits files, controlling who can access them, giving each file a unique identity, automatically archiving files when they reach a designated age and managing a central collection of "boilerplates" that users can insert into their documents.

"This is going to change the industry," Howard says. "First of all, there is nothing else like this. And it has applications in all sorts of vertical markets, like the legal industry and the medical industry."

Introduced earlier this year, FACS is already taking the legal industry by storm, Howard says. Among the first to buy the new product were some of the nation's largest law firms. They were impressed, Howard says, by FACS' ability to quickly bring order to the chaos often created by the thousands of letters, briefs, contracts and other documents a

big firm can generate in an average week.

Creating successful products like FACS and RAF takes a combination of skill and the ability to spot unfilled niches in the computer market, Howard says. He adds that luck—in particular, the good fortune to introduce a new product when the industry is ready for it—is not an insignificant factor.

But Howard is quick to note that good products alone do not a good company make.

"We don't have the attitude here that our company is a bunch of products," he says. "Our company is a bunch of people. You can take my products away, but don't take my people away. If you take my products away, I'll have new products in a year or two. If you take my people away, I'll have nothing."

Howard says he learned from his father that people are the key to long-lasting success in business. For Datability, part of the formula for keeping good people is keeping them happy. The company owns vacation houses in the Hamptons and the Berkshires and rents bed-and-breakfast inns in ski country in the winter, all of which are available to employees.

"But it's not just the money and the perks," Howard says. "It's saying we really care. It's saying that while you're having fun here at work and making good money, we also want your quality of life to be good. I want to be able to ask them for a lot, but I want them to be able to expect a lot in return.

"I don't believe it's going to be necessary to change this concept. I think it will always be this way. And I take a lot of pride in that because I believe a lot of a company's identity depends on the CEO. If I'm not willing to work hard, work nights, I can't expect my people to. If they see me cleaning papers off the floor, I don't have to feel bad when I say, 'Hey, can you grab that?' or, 'Let's straighten that out.' As long as we have that attitude, I think we will prosper."

With the success that Howard and his employees have wrought through their products and services, it may seem at times that Datability is that rarest of companies—one that can truly do no wrong. But Howard quickly brushes that notion aside.

"There are many things that get hidden by success," he says, "including all the bad decisions. There was a time when I couldn't do anything wrong, or at least it didn't seem I could. And yet, realistically, there were lots of things going wrong."

Howard remembers one decision that almost ended Datability's rise before it had hardly begun. While negotiating a contract with a major time-sharing client, Howard proposed some terms that would have made it very costly for the client to terminate the deal. The client turned the tables by canceling the contract the very next day.

"I am truly driven. I want everything I do to be the best I can make it."

"I learned very early in my career that that isn't the way one conducts oneself, and I've never done it again," he says. "Then I learned another valuable lesson: once you've lost a client, there is nothing that says you can't try again. I went back and we got the business, but on much more favorable terms for the client."

Taking the high road in his business dealings is something that Howard says he has come to believe in fervently, and not only because it makes good business sense. Since his company is located in Manhattan's Garment District, just a short cab ride from Wall Street and its financial wheelers and dealers, Howard says he is particularly sensitive to the issue of ethics.

"There's a lot of talk on Wall Street about a grey line and where one crosses it," Howard says. "I think that's a bunch of crap. The truth of the matter is, most people don't inch across a grey line, they jump two feet over it. When you feel it in your gut and you know it's wrong, you just don't do it. That's the way we are.

"It sounds like a noble stance to take, but the truth of the matter is it's a combination that works. It is a freedom that I have. I can hold my head up. I can sleep at night. It's a terrific feeling."

When Howard speaks of his ethical beliefs, his business philosophy or his entrepreneurial spirit, the conversation frequently turns to WPI.

"I learned a lot of these feelings from the way my father raised me, but they also come from the WPI experience—and not just the academic side."

One thing he gained from his years at WPI, he notes, is a passion for work.

"You saw it everywhere at WPI," Howard says. "It was the chemical engineer who loved what he was doing, who was into his science. It was the computer science majors who worked through the night, who loved tinkering, trying new things, playing off each other. There was a passion about everything.

"Because of that experience, I am truly driven. I think that is my motivating force. I want everything I do to be the best I can make it. And, I want my company to do the best it can."

Howard says he sees the same qualities—the mark of WPI, so to speak—in his partner and long-time friend.

"Richard Rupp is the brightest person I have ever met in this industry," Howard says. "There may be people who are better electrical engineers, who may write better code. But he is so good in so many different areas. He is the glue of this company. To have him at the top with me—I couldn't ask for more."

Howard's loyalty to his alma mater is reflected in many ways, from the color scheme of his office (maroon and grey) to his recent donation of equipment and software valued at nearly $250,000 for WPI's new campus computer network.

It may be reflected most poignantly in the Ichabod Washburn Award—given to outstanding young alumni—which he received in 1984 and which is now proudly displayed near his desk, alongside his cherished deep-sea fishing trophies.

"It was particularly funny my receiving that award, considering my academic record," Howard says with a grin and a note of pride in his voice.

Ron Howard may not have been a model student. But, if his success in the last decade is any indication, he is well on his way to becoming a model graduate.

MEMORY BANK

How a Landlocked College Joined the Navy

Not since WPI opened its doors had classes begun so early. But World War II would not wait for leisurely summer vacations. Though the break had begun less than a month before, on July 1, 1943, the new academic year got under way.

The sense of urgency was heightened by a new presence on campus—the U.S. Navy. That summer, 45 years ago, the Navy established a unit of its V–12 program at WPI. Over the next three years, the unit would graduate 767 officer candidates.

During the war, the armed services contracted with a number of colleges and universities for special training programs. WPI was one of only 22 schools to provide engineering training through the V–12 program. The program enabled WPI to remain open during a period when draft boards drastically reduced the student bodies of many colleges.

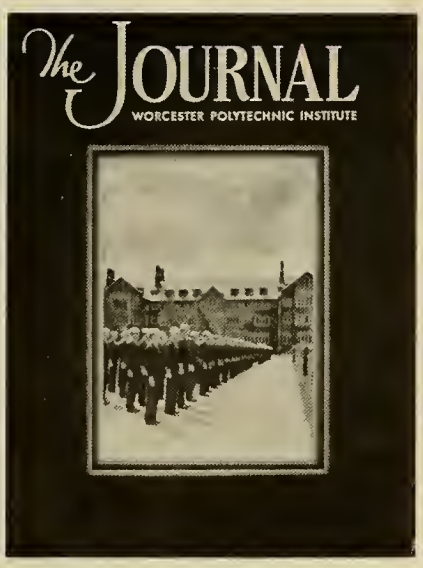
"A nation at war needs engineers," said WPI president Wat Tyler Cluverius. "Stay in college until they call you."

Cluverius, a retired rear admiral, was instrumental in convincing the U.S. government to establish the V–12 unit at WPI. Now, he would see the fruits of his efforts.

On that hot July day students-turned-sailors quickly experienced the "hurry up and wait" syndrome that has characterized military life through the ages. First they stood in line for physicals, then for uniforms, then to register, then to buy books. Through the confusion, Navy chiefs barked unfamiliar commands and salty terms not often heard among the halls of ivy.

Many of the new sailor-scholars were members of WPI's classes of 1944 and 1945. Others arrived from a half-dozen colleges from throughout the Northeast. Of the 625 students enrolled at WPI that year, 320 were in uniform.

The Navy took over Sanford Riley Hall, then WPI's only residence hall, and converted the old mechanical engineering building (now known as Stratton Hall) into military barracks. The location proved to have one important drawback.



The WPI Journal *recorded the arrival of the Navy's V–12 program, which enabled engineers to train during World War II.*

By Roger N. Perry Jr.

Next door the foundry (now the Project Center), like every other manufacturing facility in the U.S., had been pressed into service to meet wartime production requirements. The soot from the foundry's cupola belched forth each day and found its way into Stratton Hall, where it did little to enhance the appearance of the students' white Navy uniforms. A large metal "doughnut" soon appeared atop the stack that trapped most of the soot particles with a water spray.

Since Sanford Riley had gone Navy, civilian freshmen found themselves facing the problem of where to live. The fraternity houses, which were losing many members to the military, seemed the logical choice. During a six-hour Sunday afternoon rush period, freshmen toured the houses. At 6 p.m. they indicated their choices. An hour later, they moved in. Somehow it all worked.

As the war progressed, draft boards began canceling engineering student deferments and the number of civilian students at WPI dwindled. In time, Navy students dominated every class and campus activity. Still, conflicts were few. Much of the credit for the smooth integration of the two groups of students belonged to Naval Reserve Lt. Albert J. Schwieger, who took a leave of absence from WPI's Department of Economics, Government and Business to head the college's V–12 unit.

The infusion of new people proved a boon to WPI athletics. In fact, during the fall of 1943, WPI beat Harvard 13–0 at football. A popular Boston sports writer noted that at Harvard, football was "informal" that season. "Football at Worcester Tech has always been informal," he added, perhaps looking back to the 1941 and 1942 seasons when WPI won no games at all.

WPI's V–12 veterans include William R. Grogan, current dean of undergraduate studies; Owen Kennedy, dean emeritus; and associate professor emeritus Charles R. McNulty, who as a chief petty officer was assigned to WPI as a physical training instructor. He never left.

Seven current or emeritus trustees were also among the ranks: Vice Chairman Irving J. Donahue '44, Walter J. Bank '46, John Lott Brown '46, William P. Densmore '45, Anson C. Fyler '45, John E. Hossack '46 and John C. Metzger, Jr. '45.

The last V–12 students left campus in June 1946 to be replaced by returning World War II veterans, many of them former WPI students taking advantage of the GI Bill to complete their interrupted educations.

Roger Perry '45 retired recently as director of campaign communications at WPI. He is a retired commander in the Naval Reserve and served at sea in both World War II and the Korean War.

FINAL WORD

Sound is Music to His Ears

By Bonnie Gelbwasser

Stephen N. Jasperson teaches the sound of music, but don't expect to find him leading a crowd of children dressed in folk costumes in a chorus of "Do Re Mi."

Jasperson, the amiable head of WPI's Physics Department, is part of a trio of Worcester-area college professors who teach a yearly undergraduate seminar on electronic music.

With a Ph.D. in physics from Princeton University and impressive credentials as a researcher on such topics as the optical properties of solids, he might be forgiven if he felt a little uncomfortable surrounded by contemporary rhythms. Jasperson, however, is right at home.

"I'm involved in this area because I'm interested in physics and I'm also interested in music," he says. "A big chunk of that small portion of time I spend in nonprofessional activities is directed to things musical. I sing in the Worcester Chorus and I play the piano a bit."

But even more, Jasperson notes, he is deeply interested in the physics of sound.

"Sound is something we all take for granted," Jasperson says. "Unless something happens to our sense of hearing, we don't think twice about it. There are sounds all around us. We communicate with sounds. We use sound to detect if something is going wrong with our car or appliance. My interest is in the things that are fundamental to the nature of sound and to its production and perception. I like to tell my students: 'I hope you never hear sound the same way again.'"

Because of his orientation, Jasperson teaches the scientific aspects of the course. The musical perspective is imparted by Wesley Fuller, associate professor of music at Clark University, and Shirish Korde, chairman of the music department at the College of the Holy Cross.

More than a decade ago, the three joined forces to form the Tri-College Group for Electronic Music, which not only offers the course, but obtains grants to purchase equipment and sponsors an annual concert featuring compositions by Korde and Fuller.

Jasperson and Fuller began teaching the seminar after each independently developed an interest in electronic music in the early 1970s. Jasperson was drawn to the technical challenge of creating sounds electronically. His interest grew as he began to advise students who wanted to build electronic circuits to synthesize sound.

Later, Jasperson learned about Fuller, who, having attended a summer course on computer-generated music at Colgate University, had decided to try his hand at composing for electronic instruments.

"We began collaborating on a course to overcome our respective areas of ignorance," Jasperson says.

Not long after the course got off the ground, Jasperson learned of WPI alumnus Alan R. Pearlman '48, an electrical engineer who had helped found ARP Instruments, a Boston-based maker of electronic synthesizers.

"We got in touch with Alan and learned that he was preparing to donate some synthesizers to the college," Jasperson says. Pearlman ultimately gave WPI four machines, including an ARP 2600, which was then being used by many preeminent performing and recording artists.

Today, thanks to the efforts of the Tri-College Group, there are electronic music studios at all three colleges. The

Physics Department Head Stephen N. Jasperson seated in WPI's electronic music laboratory in Olin Hall.

JANET WOODCOCK

group members also share equipment, as needed.

WPI's studio occupies part of a laboratory in Olin Hall, WPI's physics building. In addition to an ARP synthesizer, there is a Yamaha digital synthesizer, a four-track tape recorder and a Macintosh Plus computer, among other equipment. The lab is staffed several hours each week and is available to students for pleasure as well as education, Jasperson says.

The equipment in the WPI lab spans the history of modern electronic music. The ARP machine is an analog synthesizer. To play it, one uses patch cords to build circuits, much like an operator linking callers on an old fashioned switchboard. With the circuits one creates and modifies electronic waveforms that are analogs of the desired sound. The computer is the most modern way of making sounds electronically. The computer software represents waveforms numerically, converting them to electrical waveforms only as a final step.

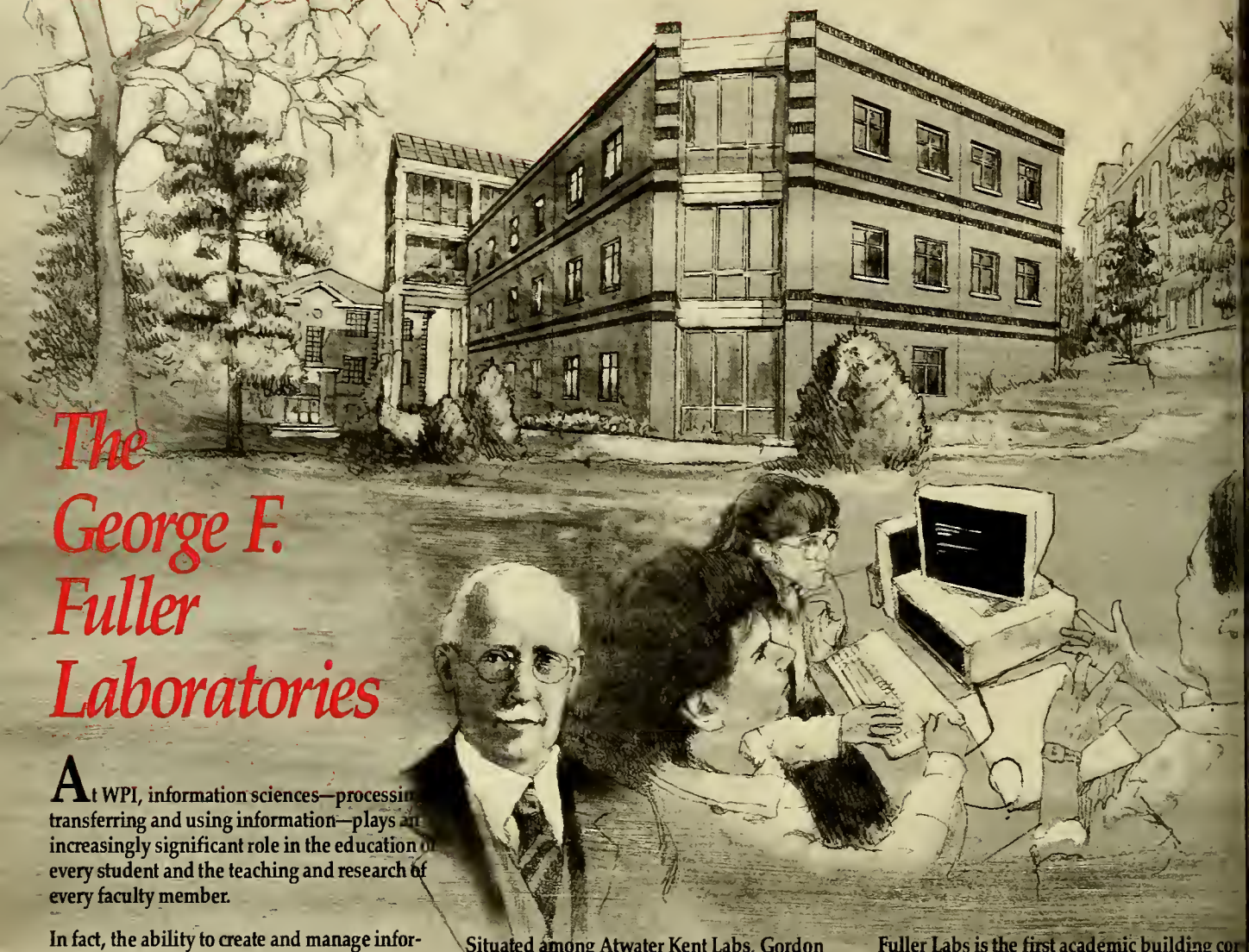
In his portion of the Tri-College course, Jasperson uses analog and digital instruments, along with laboratory equipment that can analyze and visually represent sound, to give students a grounding in the physics of the sounds that emanate from synthesizers.

"Electronic music has two sides: music and technology," he says. "You are limited in what you can do if you aren't knowledgeable in both areas. The more one knows about the physical attributes of sound, the more successfully one can synthesize specific sounds by electronic means."

And, Jasperson says, the more one knows about sound the more one can appreciate music in general. His own tastes run toward classical music rather than modern rock, though he says he tries to keep an open mind when it comes to sound.

"There's invariably something interesting to find in all sound," he says. "I really try to enjoy it all."

EXCELLENCE IS...



The George F. Fuller Laboratories

At WPI, information sciences—processing, transferring and using information—plays an increasingly significant role in the education of every student and the teaching and research of every faculty member.

In fact, the ability to create and manage information will largely determine the success of tomorrow's scientists and engineers as well as the vitality of high technology and the entire American enterprise.

Today, WPI is taking a major step toward accommodating its growing needs in computer science, faculty scholarship, and academic and administrative computing. Construction of the George F. Fuller Laboratories will bring under one roof the expanding initiatives of the Department of Computer Science, while freeing up much needed space elsewhere on campus for programs in electrical and mechanical engineering, the humanities, and the Institute's library collections.

Situated among Atwater Kent Labs, Gordon Library and Kaven Hall, the 53,000 square foot facility will house advanced undergraduate teaching labs and dedicated research space in computer science, materially enhancing this growing program and helping the Institute in perhaps its most competitive field of faculty recruiting.

Some 70 professors and support staff will have office space in Fuller. And the centers for academic and administrative computing will find new homes there, creating greater synergy and keeping service costs to a minimum.

Finally, the Instructional Media Center will move to Fuller, and a multi-purpose, 400-seat lecture hall will fill a gap long felt on campus.

The key physical facilities project in WPI's current $52.5-million *Campaign for Excellence*, Fuller Labs is the first academic building constructed at the Institute since 1967. Since then five of the campus's six original buildings have been fully renovated to accommodate the latest educational imperatives.

To the late George F. Fuller, the pursuits embodied in the Labs would have delighted the inventive genius of this former president Wyman Gordon Co. and, for 29 years, a trustee of WPI.

Aided significantly by a grant of $2 million from the George F. and Sybil H. Fuller Foundation, together with a challenge grant from the Kresge Foundation and the support of many other donors, in constructing Fuller Labs WPI is enabling student and faculty scholars to reach for the future as never before.

You, too, can play a part in this exciting future

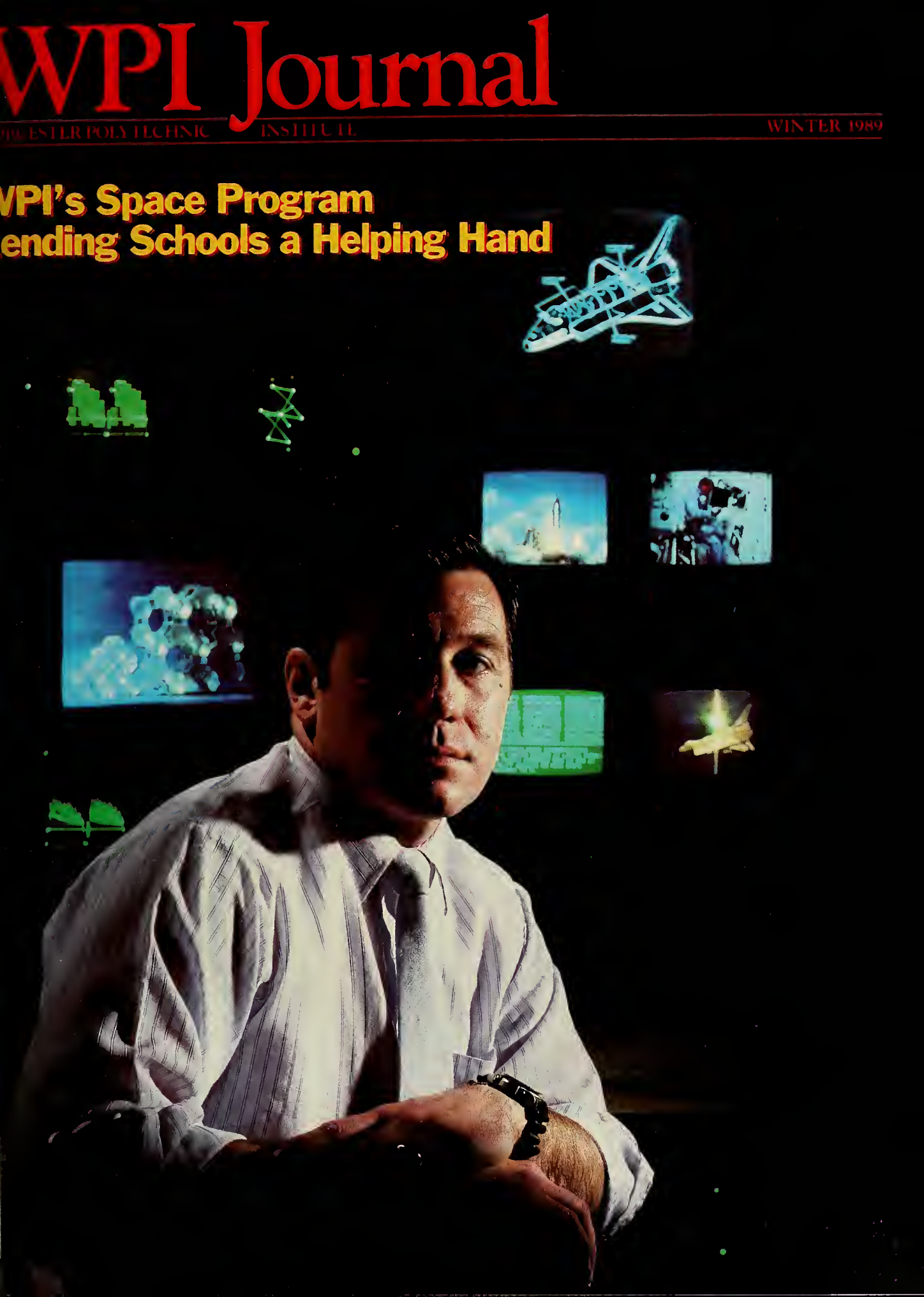
Support the Campaign for Excellence

WPI Journal

ORCESTER POLYTECHNIC INSTITUTE

WINTER 1989

WPI's Space Program ending Schools a Helping Hand



A wintry scene frames the tower of the Washburn Shops. Photo by Robert S. Arnold. Black-and-white 8-by-10-inch prints of this photo are available; send $10 to WPI Journal, 100 Institute Road, Worcester, MA 01609-2280.

WPI JOURNAL

CONTENTS

VOLUME XCII NO. 1
WINTER 1989

Staff of the WPI Journal: Editor, Michael W. Dorsey • Alumni Information Editor, Ruth S. Trask

Alumni Publications Committee: Samuel Mencow '37, chairman • Paul J. Cleary '71 • James S. Demetry '58 • Judith Donahue, SIM '82 • William J. Firla, Jr. '60 • Maureen Sexton Horgan '83 • Carl A. Keyser '39 • Robert C. Labonté '54 • Roger N. Perry Jr. '45.

The WPI Journal (ISSN 0148-6128) is published quarterly for the WPI Alumni Association by Worcester Polytechnic Institute in cooperation with the Alumni Magazine Consortium, with editorial offices at the Johns Hopkins University, Baltimore, MD 21218. Pages I–XVI are published for the Alumni Magazine Consortium [Johns Hopkins University, Villanova University, Western Maryland College, Western Reserve College (Case Western Reserve University), Worcester Polytechnic Institute] and appear in the respective alumni magazines of those institutions. Second class postage paid at Worcester, MA, and additional mailing offices. Pages 1–16, 33–48 © 1988, Worcester Polytechnic Institute. Pages I–XVI © 1988, Johns Hopkins University.

Staff of the Alumni Magazine Consortium: Editor, Donna Shoemaker • Wrap Designer and Production Coordinator, Cecily Roberts • Assistant Editor, Sue DePasquale • Consulting Editors, Alan Sea and Elise Hancock • Core Designers, Allen Carroll and Cecily Roberts.

Advisory Board of the Alumni Magazine Consortium: Johns Hopkins University, B.J. Norris and Alan Sea • Villanova University, Eugene J. Ruane and D.M. Howe • Western Maryland College, Joyce Muller and Sherri Kimmel Diegel • Western Reserve College, David C. Twining • Worcester Polytechnic Institute, Michael Dorsey.

Acknowledgments: Typesetting, BG Composition, Inc.; Printing, American Press, Inc.

Diverse views on subjects of public interest are presented in the magazine. These views do not necessarily reflect the opinions of the editors or official policies of WPI. Address correspondence to the Editor, The WPI Journal, Worcester Polytechnic Institute, Worcester, MA 01609-2280. Telephone (508)831-5616. Postmaster: If undeliverable please send form 3579 to the address above. Do not return publication.

3 **Out of this World** *Michael W. Dorsey*
Student projects and faculty research are launching WPI into the Space Age.

10 **Growing Crystals in the Final Frontier** *Michael W. Dorsey*
Research team's dream of record-size zeolites rides on a new NASA laboratory.

14 **From Lindbergh to Sputnik** *Roger N. Perry Jr.*
Kenneth Merriam's aero option spanned the history of modern aviation.

I **Ode to the Eighties**
Well-versed in wit? Enter our limerick contest.

II **The Smart Assembly Line** *Sue De Pasquale*
Non-contact testing could transform manufacturing.

IX **The Long Wait for a New Life** *Lavinia Edmunds*
There aren't enough donated organs to go around.

33 **Confronting a Crisis in our Schools** *Michael V. Shanley*
A new WPI center is helping public schools get kids excited about science and math.

43 **The Entrepreneurial Spirit: Seizing the Day** *Amy Zuckerman*
Gerald Finkle's formula for success is simple: make the most of opportunities.

DEPARTMENTS

2 **Advance Word:** A prelude to space.

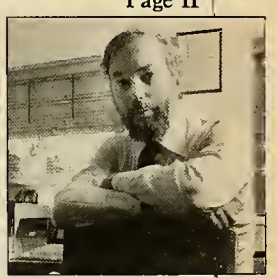
47 **Explorations:** Stellar performances; making math easier.

48 **Final Word:** The Magnetic Lab keeps its secrets. *Bonnie Gelbwasser*

Page 3

Page I

Page II


Page 33

Cover: Albert Sacco Jr., professor of chemical engineering, heads a WPI research team that is designing a zeolite crystal growth experiment for a new NASA space laboratory. Story on page 10. Photo by Robert S. Arnold.

ADVANCE WORD

A Prelude to Space

The age of rocketry was launched by WPI's most famous graduate

Like the Wright Brothers, who completed their historic first powered flight less than a year before he enrolled at WPI, Robert H. Goddard had a vision of freeing mankind from the bounds of Earth. But while the Wrights mastered the air, Goddard dreamed of conquering space and the universe beyond. While the rockets he built in later years never climbed beyond the atmosphere, his work made the Space Age possible.

During his four years at WPI, Goddard laid the groundwork for his seminal career. He was an exceptional student, one who kept his professors on their toes with probing questions about physics, chemistry, physiology and engineering. He showed a notable proclivity for invention, devising, for a class theme, a plan for a magnetic train that would travel thousands of miles an hour through an evacuated tube. Later, he published in *Scientific American* what is thought to be the first proposal for the use of gyroscopes to stabilize airplanes.

And, he filled countless notebooks with informed speculations on space travel. He wondered, for example, about a propulsion system that might lift a man free of the pull of the Earth's gravity, about systems that might support life outside of the atmosphere, about methods for slowing a speeding spacecraft so it could land on another world, and about techniques that might suspend human life on long space flights.

At WPI, Goddard took several giant steps on a journey that had begun years earlier with a vision, experienced while he trimmed limbs from a cherry tree behind the family barn in 1898. He imagined a device that could travel from Earth to Mars. The realization of that vision would take him to a field at his Aunt Effie's farm in Auburn, Mass., on March 16, 1926.

There, on a cold afternoon, he launched the world's first successful liquid-fueled rocket, which rose 41 feet and traveled 184 feet from its launching frame. The event was to signal the beginning of the Space Age just as clearly as the Wright Brothers' first flight had heralded the age of flight. (Goddard would later compare the two events proudly, noting that the Wright Brothers had managed to fly their craft just 120 feet at an altitude of a mere four feet.)

Before turning to liquid-fueled rockets, Goddard, then a professor at Clark University, worked on prototypes of a "machine-gun" rocket that would be propelled by firing cartridges filled with explosive powder. Some tests were carried out in WPI's Magnetic Laboratory (page 48).

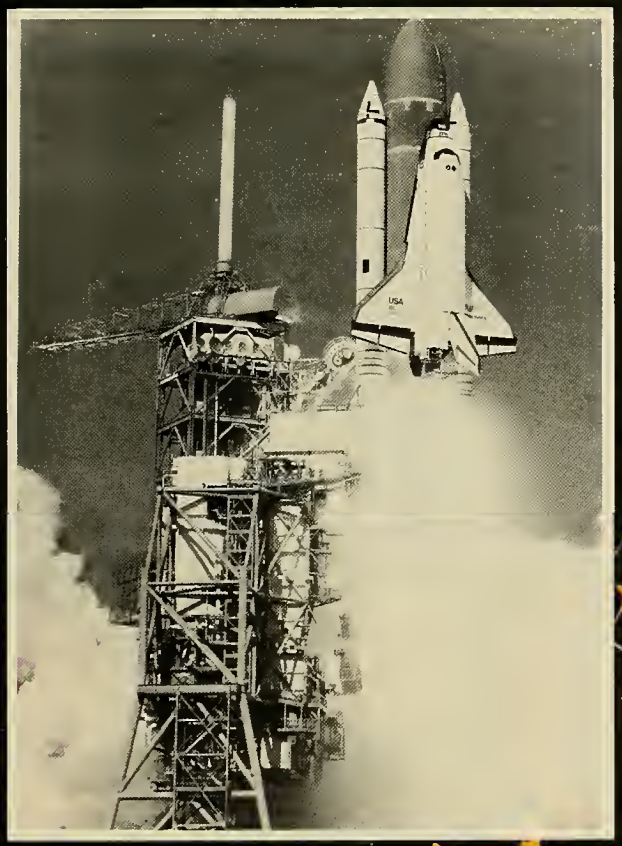
Like many pioneers, Goddard received little recognition during his lifetime. However, as the lure of space captivated the U.S. after World War II, it became apparent that through his work, as well as his keenly perceptive ruminations on space travel, Goddard had not just launched the Space Age, but had been an amazingly accurate prophet of its achievements.

Recognition did come eventually. Congress ordered a special gold medal struck to honor his work. He received, posthumously, the rarely-awarded Langley Medal for his achievements in aerodynamics. The American Rocket Society and the American Institute of Aeronautics and Astronautics named awards in his honor.

Goddard professorships have been created at a number of American universities and Clark University named its library for him. WPI named its chemistry and chemical engineering building (a gift of the F.W. Olin Foundation) for Goddard, as well as an alumni award for professional achievement.

The most notable structure to bear Goddard's name is NASA's Goddard Space Flight Center, dedicated in 1961, exactly 35 years after Goddard's first liquid-fueled rocket rose from the field in Auburn, Mass. The center, covering 500 acres and employing some 2,000 people, buzzes with advanced research on space flight systems. It is, perhaps, the most fitting tribute to a man who took space travel from the pages of science fiction and made it a reality.

Robert H. Goddard '08 in 1926 with the first successful liquid-fueled rocket.



Out of this World

NASA PHOTOGRAPH

Through student projects and scholarly research, WPI is building its own "space program"

One morning last September, the space shuttle Discovery sat quietly on launch pad 39-B at the Kennedy Space Center. Swathed in clouds of vapor, the 12-story space plane was poised to rocket into orbit, ending a two-year hiatus in the American manned space program.

At WPI, students and faculty hovered near television sets and waited as unusually calm high-altitude winds delayed the launch into the early afternoon. When the shuttle finally rose on a roiling pillar of flame, tense observers all over campus urged it on, quietly willing the spacecraft into orbit.

For many of those faculty members and students, the successful launch of Discovery represented more than America's return to space. The resumption of the shuttle program was a long-awaited shot in the arm for WPI's own space program.

During the last six years, hundreds of undergraduates, some 30 faculty members and several graduate students have labored on projects and experiments which focus, in one way or another, on the conquest of space. More than 250 students have designed and built experiments that will fly into orbit in the cargo bay of the Discovery or one of its two sister shuttles.

The projects will occupy the five cubic feet of space inside of an aluminum cylinder known as a Getaway Special Canister or GASCAN. GASCANs were created by NASA to offer universities and corporations an inexpensive route to space.

WPI's first GASCAN was ready to fly soon after the ill-fated final flight of the shuttle Challenger and is now expected to go aloft as early as the end of this year. Another set of GASCAN experiments is in development and should be ready for launch in a few years.

Had the GASCAN project program done nothing more than open a brief window on space for WPI, it would have been a tremendous success. But it has accomplished far more than that. Just as the space program itself generated a myriad of spinoffs, WPI's first steps into space have set in

BY MICHAEL W. DORSEY

PETER CRONIN

(Left to right) Robert C. Labonté '54, WPI President Jon C. Strauss, MITRE's William Zimmer, Dino Roberti '85 and William W. Durgin, professor of mechanical engineering, at a contract signing ceremony for GASCAN II in 1985.

motion a host of sophisticated research efforts and student projects, some of which may see WPI return to space many times in the years ahead. It has helped vitalize a renewed undergraduate aerospace engineering concentration. And, it has earned WPI a respected niche in the space research community.

The lecture hall was crowded as William Zimmer, associate technical director at MITRE Corporation, a nonprofit federal contract research center in Bedford, Mass., stood before an attentive group of WPI faculty members in the fall of 1982. Zimmer and Robert C. Labonté '54, associate department head at MITRE, had come to make WPI an offer. MITRE had purchased a GASCAN from NASA and was willing to let WPI's faculty and students fill it with experiments. MITRE also included a $20,000 grant to WPI to help defray the cost of developing the experiments. It was, in effect, free passage aboard a future shuttle mission for up to 200 pounds of WPI cargo.

"While MITRE works extensively with the technical side of NASA's business," Labonté says, explaining the corporation's rationale for donating the shuttle ride to WPI, "we are less familiar with its operational side. We knew that if we could be involved with a GASCAN, even indirectly, it would allow us to develop a working relationship with NASA's operations people."

Zimmer and Labonté found an enthusiastic crowd that included Fred J. Looft, associate professor of electrical engineering. Looft was familiar with the work that goes into a space experiment. His father designed and tested rockets at the NASA Lewis Research Center in Cleveland. As a Ph.D. candidate at the University of Michigan, Looft had helped build a human physiology experiment for NASA's Space Lab. And he had applied to become a mission specialist in the shuttle program.

"I stood up and said,'Don't worry about the money. We have an offer on the table. If we pass it up, we'll never get another one like it,' " Looft remembers.

Francis C. Lutz, professor of civil engineering and associate dean of undergraduate studies, saw in the MITRE proposal the potential for a program that could pay multiple dividends for WPI.

"I knew it would be expensive and take several years, but the educational advantages were just superior," he says. "It would require experimental work that continues from year to year, where students build on the progress of other students and where students from different disciplines work together to complete working experiments."

Within a few months, Zimmer and then WPI president Edmund T. Cranch put their signatures on a contract and the WPI/MITRE Space Shuttle Program was born.

From the start, competition was a driving force in the WPI shuttle program. The first group of students was selected from a pool of applicants through a competitive process. They rolled up their sleeves and began work on 12 experiments, knowing full well that fewer than half would ever fly on the shuttle.

During the next several years, dozens of student teams completed their Major Qualifying Projects (MQPs) as the experiments moved from designs to initial mock-ups to working prototypes to flight-ready hardware. Along the way, some projects, having run into hurdles or dead ends, fell by the wayside.

These included a solid-state camera for studying Earth resources, a fiber-optic ring gyroscope to measure the rotation rate of objects in space and an engine driven by the tendency of a nickel-titanium alloy known as nitinol to change shape with changes in temperature.

Four experiments survived the final cut (see illustration, next page). One will attempt to grow large zeolite crystals (page 10). Another will study the behavior of fluids in microgravity. A third, called the Environmental Data Acquisition System, will record information about sound, light, temperature and pressure within the GASCAN. The fourth will measure the acceleration of the shuttle along three axes with a high degree of precision.

Another experiment, this one designed by Looft and his young neighbor, Clay Rives, now an eighth-grade student in the Worcester Public Schools, will determine how solar radiation fogs photographic film beyond the protection of the Earth's atmosphere.

Other project teams developed devices to record and decode data from the experiments as well as a structure onto which the experiments, recording devices, power supplies, batteries and other support equipment would be bolted.

The structure's initial design was completed by Joel K. Kearns '84, who is now a program manager at NASA headquarters in Washington, D.C. Another student, Thomas W. Broderick '84, spent many painstaking hours at a computer terminal completing a finite element analysis of the structure to prove that it could meet NASA standards. Finally, the structure, as well as cases for the experiments and other equipment, were constructed by technicians at MITRE.

Try this experiment: pull on a pair of bulky gloves and try to thread a needle. The frustration you feel will give you an idea of the difficulty astronauts experience as they try to do work in modern space suits. In 1983, NASA challenged U.S. college students to design a better space glove.

Several schools submitted proposed designs, but NASA selected just four for further development. Among them was a design created by students at WPI. Working on their MQPs, nine students built and tested a working prototype, a process that required more than eight months. In the spring of 1985 the students traveled to Washington with eight faculty advisors to present the design to a panel of judges.

"That was quite an exciting thing, to actually have students go to Washington to compete in a design competition," remembers William W. Durgin, professor of mechanical engineering and lead advisor for the team.

WPI did not win the design award, but the experience, along with the enthusiasm generated by the growing WPI/MITRE Space Shuttle Program, helped fuel a surging interest in aerospace engineering at the college. That was good news for Durgin, who had recently helped launch and now directed a new aerospace option at WPI, which had not offered an "aero" concentration for nearly a quarter of a century (page 16).

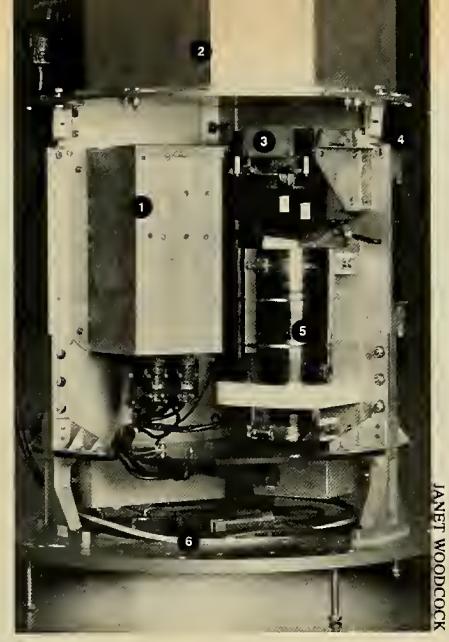
"We envisioned a program that would serve about 20 students per year," says Durgin, an expert in fluid mechanics who spent 12 years at the Alden Research Laboratory in Holden, Mass., as a research engineer before moving to the WPI campus. "We had no way of knowing how popular it would become."

The first year about 14 students selected the option, Durgin remembers. But the program's popularity quickly grew. In time, nearly half of the new mechanical engineering majors were choosing the aerospace concentration.

"This is not a phenomenon unique to WPI," Durgin says. "Interest in aerospace engineering is skyrocketing at many engineering colleges."

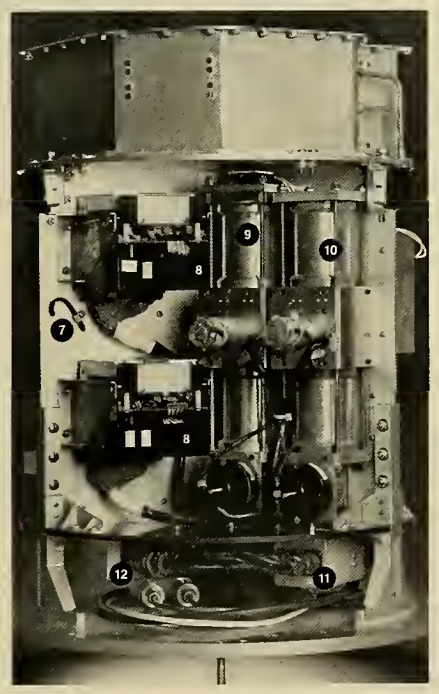
In part, Durgin says, this is due to the promise of new jobs in a field that virtually collapsed when the Apollo program ended in the mid-1970s. But there seems to be something else behind the trend.

"The last Apollo astronaut walked on the moon in 1972," Durgin says. "Few of these kids remember that. They've grown up with the shuttle, but they've also seen

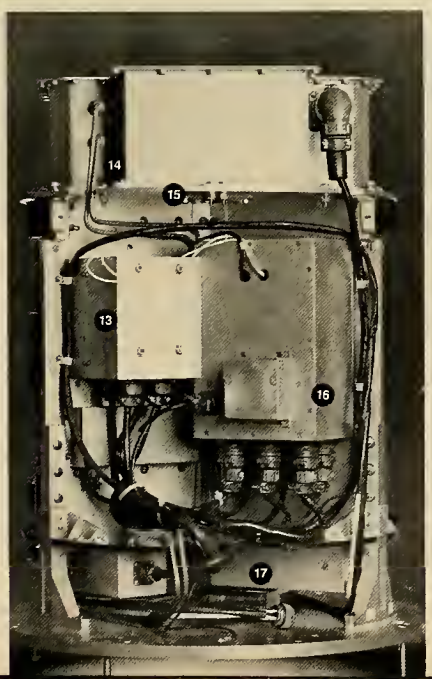


JANET WOODCOCK

The photographs on this page depict the interior of WPI's GASCAN I, a set of experiments and associated hardware that will fly on a space shuttle. The structure is three feet high and 18 inches in diameter and weighs about 170 pounds. Shown in this photo are the: (1) Environmental Data Acquisition System (EDAS), (2) battery compartment, (3) data recorder for EDAS, (4) side supports for mating with outer canister, (5) zeolite crystal growth experiment, (6) pressure relief valves for battery compartment.



Seen in this second view are the: (7) temperature sensor for EDAS (other sensors located in the GASCAN feed information about pressure, sound and light to EDAS), (8) data recorders for the fluid behavior experiment, (9) fluid behavior experiment: wetting fluid cylinder, (10) fluid behavior experiment: nonwetting cylinder, (11) power distribution control hardware, (12) temperature controller for the zeolite crystal growth experiment.



In this third view are seen the: (13) power converter for the fluid behavior experiment, (14) over-pressure vent lines for the battery compartment, (15) film fogging experiment (other film holders are located in other spots and in other orientations in the GASCAN), (16) controller for the fluid behavior experiment, (17) triaxial precision accelerometer. The GASCAN structure seen here will be delivered to NASA shortly before launch to be inserted into an external aluminum canister.

the Russians establish a permanent presence in space. The Russians have launched new Mars probes; they have a launch capability that far exceeds ours; they have a successful space station. Maybe we are seeing the younger generation rising to the occasion where we failed."

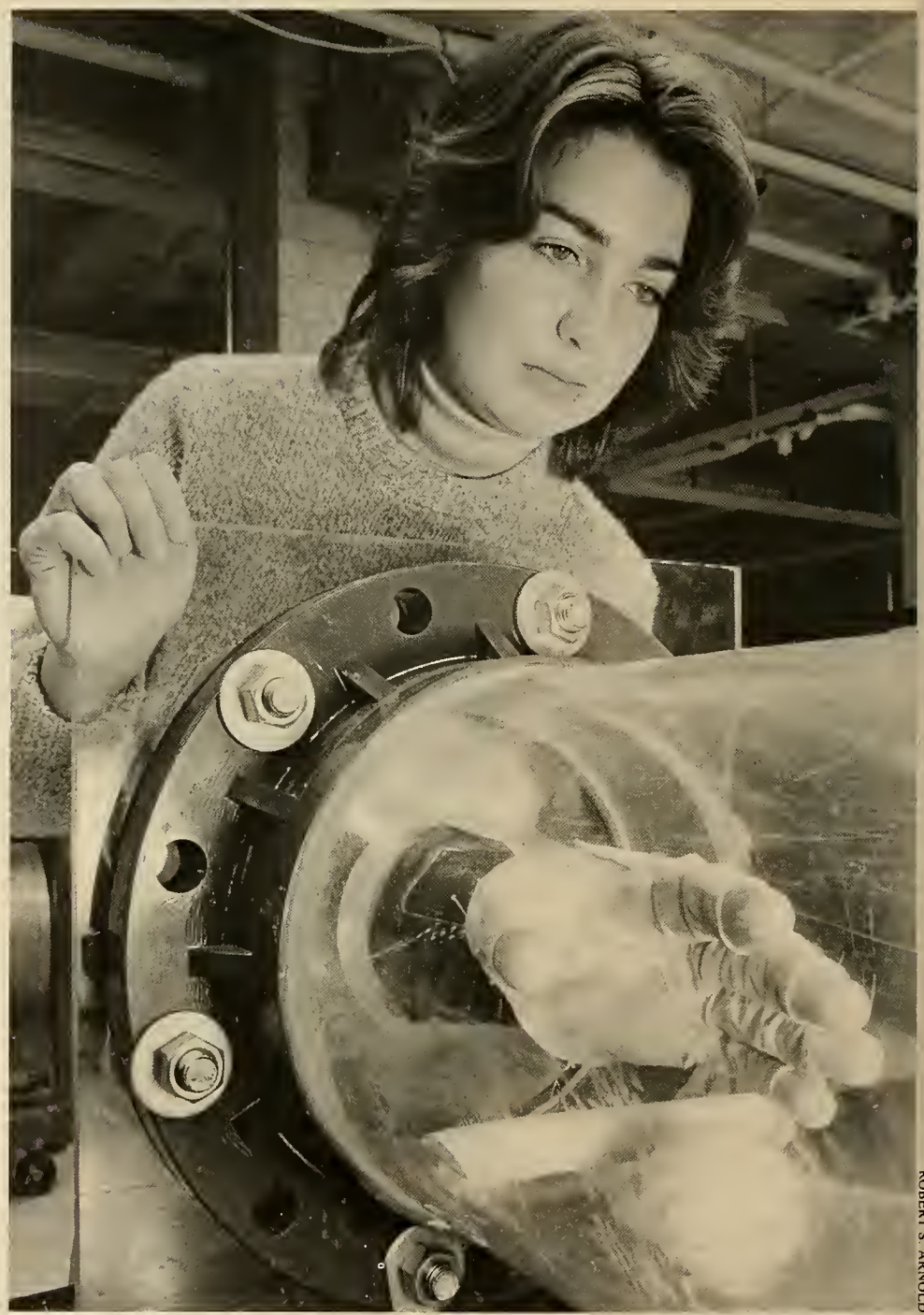
To support a growing aerospace program, WPI faculty must provide a steady stream of ideas for projects in aeronautics and space studies. A limited number is available through the WPI/MITRE Space Shuttle Program, but not enough to serve dozens of aero majors. Fortunately, in 1986, NASA provided some help.

After the success of the space glove competition, the agency decided to foster further interaction between NASA and universities. The result was a new program administered by NASA's University Space Research Association (USRA), which gives undergraduates the opportunity to work on advanced engineering design projects related to missions that NASA hopes to launch within the next three decades.

"The center is NASA's response to concern among members of the engineering community that higher education in engineering focuses on engineering science at the expense of engineering design," Durgin notes.

NASA's interest in design proved an excellent match for WPI's own commitment to maintain a strong emphasis on design in the undergraduate curriculum, according to Frank Lutz.

"We wanted the undergraduate projects program to have an emphasis center in engineering design—the kind of interdisciplinary decision making, with all of its tradeoffs, that has to take place for one to design workable experiments," he says.



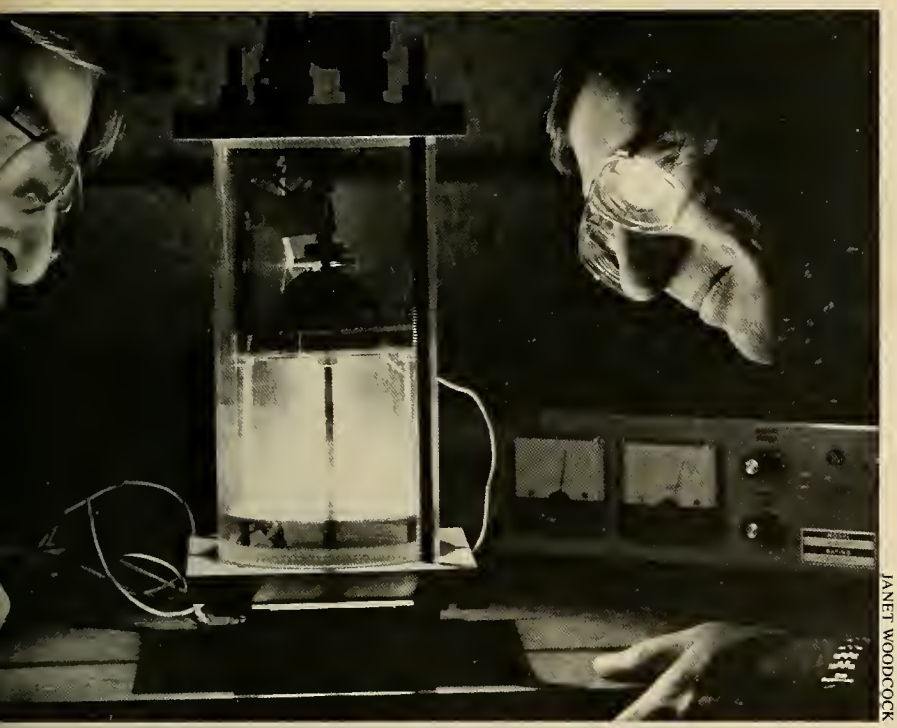
ROBERT S. ARNOLD

Andrea D. Gallant '85 was a member of a team of WPI students that designed and built a prototype of a new space glove for a design competition sponsored by NASA in 1983. The WPI glove had clips on the palm and a loop around the thumb to control ballooning and improve an astronaut's ability to grip objects.

Through the USRA, WPI received more than $20,000 to establish an Advanced Space Design (Project) Center (ASDC), affiliated with NASA's Johnson Space Flight Center. The ASDC is a focal point for a wide range of projects on advanced space missions, lunar and planetary exploration, the utilization of extraterrestial resources and other areas of concern to NASA.

One recent project being completed by Mark A. D'Angelo, Richard L. Lupien, Brian E. Perry, Matthew S. Sudbay and Michael A. Vidal, all seniors majoring in mechanical engineering, addresses the challenge of refueling spacecraft in orbit. Many new satellites are designed to have their propellant tanks refilled to extend their working lives. The students, advised by Durgin, are designing a system to make this possible.

Helping to advise the students is Peter J. Bloznalis, a graduate student in mechani-



JANET WOODCOCK

JANET WOODCOCK

(Top) Richard L.P. Custer (left) and George Y. Jumper Jr. observe a test run of a microgravity ignition experiment under development for GASCAN II. (Bottom) Randall Briggs '86 holds a sample of ilmenite, an ore found in abundance on the Moon and which may one day be mined as a source of oxygen.

cal engineering who is conducting his master's work in the area of satellite refueling. Bloznalis is also employed by the ASDC to assist undergraduates working on aerospace projects and to serve as a liaison between the students and NASA.

Another MQP, conducted by Jeffrey S. Goldmeer '89, and David P. Smith '89, and advised by George Y. Jumper Jr., associate professor of mechanical engineering, helps students better understand orbital mechanics by displaying on a computer screen a visual representation of an orbit once a set of parameters is entered. The program also demonstrates how to change orbits and rendezvous with an orbiting object.

This summer Goldmeer, who has been accepted as a graduate student in mechanical engineering at WPI and will succeed Bloznalis as the ASCD advisor, will spend 10 weeks at the Johnson Space Flight Center, along with Stacy J. Cotton '90 and Stephen L. Anderson '90, working on advanced space projects. WPI student teams work at Johnson each summer as part of the ASDC program.

Other MQPs in aerospace engineering have ranged from designs for new airplanes and spacecraft to thermal analyses of the two GASCANS to a study of artificial intelligence applications in space advised by Michael Gennert, assistant professor of computer science.

Through the ASDC, many students are also completing a wide range of Interactive Qualifying Projects (IQPs), in which they explore the intersection of science, technology and society. Some recent examples have included an analysis of the potential impact of international space treaty negotiations and space law proposals on future NASA missions (advised by John F. Zeugner, professor of history), the identification of critical technologies needed for future space exploration (advised by Durgin, Fred Looft and Albert Sacco Jr., professor of chemical engineering) and a study of the sociology of long-duration space travel and its implication for the design of future manned spacecraft (advised by Susan Vernon-Gerstenfeld, visiting lecturer, Division of Interdisciplinary Affairs, and Robert W. Thompson, professor of chemical engineering).

An ongoing IQP has kept WPI and a growing off-campus constituency informed about the progress of WPI's aerospace endeavors. Called the Technical Communications Team, the IQP effort has, since the beginning of the space shuttle project effort, produced an informative periodical, now known as the *Advanced Space Design Journal.* The team also maintains a computer database on space research for the WPI community.

Another space-related IQP served as the launching pad for a research program that may aid NASA's long-range plans to build lunar bases. In the project, Randall Briggs '86 took a look at how such bases may contaminate the moon. In the process, he became interested in just what a moon outpost might be set up to accomplish. One

likely focus identified by NASA is the production of oxygen.

"It has been estimated that in the early 21st century, 40 percent of all the cargo shipped into space from Earth will be fuel and oxygen for rockets in low earth orbit," Briggs notes. "Because of the low gravity on the Moon, one can send oxygen 240,000 miles back to Earth orbit with 1/20th the energy needed to launch it from Earth."

Briggs decided to complete an MQP with Albert Sacco, his IQP advisor, on methods of extracting oxygen from ilmenite, an iron-titanium ore that is abundant in lunar soil. The MQP, completed with $1,500 from NASA's Johnson Space Flight Center, produced promising results.

Currently Briggs is working as a graduate student with Sacco on a technique in which the ilmenite is pretreated with oxygen. Preoxidation, Briggs says, seems to make ilmenite give up its own oxygen more readily. The work has received nearly $100,000 in NASA funding over the past two years.

The morning of January 28, 1986 was a cold one by Florida standards. But the silent crowd at the Kennedy Space Center barely noticed the chill. Above them in the sky, in a hideous Y-shaped trail of smoke, was written the end of an era in the American space program.

News of the Challenger disaster spread quickly across the WPI campus that morning. One student who took it hard was Dino Roberti '85, now a Ph.D. candidate in electrical engineering. Roberti had worked on the GASCAN's fluid behavior experiment and was completing the job of pulling the pieces of the GASCAN together and making them work.

It had been a difficult task, one marked by long hours and deadlines that sometimes pushed his own graduate work to the back burner. But the GASCAN was ready. In a few months, it was hoped, it would be rocketing into orbit. All that changed on that cold January morning.

"When you've spent three years on a project, you have an interest, in your heart, in seeing it work," he says. "That's why this setback was so disappointing. Hopefully we'll get another chance this year."

Roberti's work on the fluid experiment had been a stepping stone to his graduate studies. The experiment presented an interesting puzzle: how do you determine the quantity of the fluid in a tank in the absence of gravity? On Earth, the challenge is simple: place a stick in the tank and measure the level. In space, though, fluids tend to form small drops that float about or adhere to the tank's lining.

The experiment consists of cylinders containing either a wetting fluid (which tends to adhere to surfaces) or a non-wetting fluid. Ultrasonic sensors, developed in part by Roberti, scan the interior of the tanks and measure the thickness of the liquid film. For his master's thesis, Roberti developed a more refined ultrasonic fuel gauge that measures the voids in the fuel tank. By adding up the volumes of the voids, the volume of the fuel can be determined by simple subtraction.

In late 1985, MITRE's William Zimmer and Robert Labonté again sat down to sign a contract with WPI. This one gave WPI its second ticket into space and a second grant of $20,000. In short order, work began on a new set of projects for what was dubbed GASCAN II.

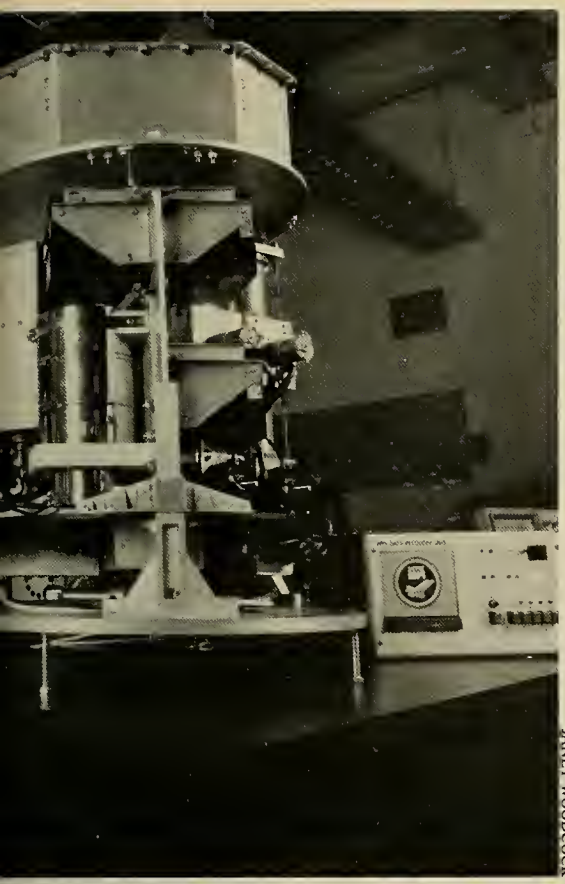
"GASCAN I was a wonderful success for MITRE," says Labonté, who had managed the day-to-day liaison between MITRE and WPI and served as an advisor to some of the GASCAN I projects. "We wanted to develop a closer relationship with WPI and its faculty. We also wanted to become more visible as an employer to WPI students. We were achieving these goals. For this reason, Bill Zimmer felt it would be an excellent idea to continue the program with a second GASCAN."

"MITRE had made a major commitment of funds and resources to WPI with GASCAN I," Frank Lutz adds. "They provided significant monetary support, in addition to the cost of the GASCAN, and they lent us the expertise of their technical staff as reviewers and advisors. We were glad that they found the effort rewarding enough to continue."

While GASCAN II would also be a competitive program, the pool of experiments was smaller, by design, Looft notes.

"With the second GASCAN we tried to pick experiments that were, first and foremost, educationally meaningful," he says. "After that, we made sure the projects were scientifically meaningful."

The projects include an ionospheric propagation experiment, advised by Looft, that will study a phenomenon known as ducting, in which radio waves between 10 and 20 megahertz bounce between layers of the ionosphere, traveling for great distances without attenuation before they return to Earth. The experiment will monitor the strength of a radio signal known as WWV, a world time standard, and correlate it with the density of the ion layers



JANET WOODCOCK

MITRE PHOTOGRAPH

(Top) Fred J. Looft (left) and Dino Roberti '85 with GASCAN I. (Left) William W. Durgin (right) and Peter J. Bloznalis with prototype experiments for GASCAN II. (Above) A student team shows off an early version of the microgravity ignition experiment after a presentation at MITRE in 1986.

JANET WOODCOCK

through which the shuttle flies.

GASCAN II will also include what is thought to be the first study of the formation of vortices under varying levels of gravity. The experiment, advised by Looft and Durgin, who is also technical advisor for the entire GASCAN II effort, consists of a fluid chamber mounted on a rotating platform. By spinning the platform at different speeds, varying levels of gravity can be simulated. Ultrasonic sensors will detect the formation of vortices.

Another GASCAN II experiment will look at a problem that is of great interest to NASA: fire in space. On Earth, gravity determines how a flame forms and spreads. Hot air rising from a flame takes combustion products away from a fire and allows fresh oxygen to feed the flame. Without gravity, hot air doesn't rise. How will this affect the time it takes for a fire to start?

Students, working with advisors Richard L.P. Custer, associate director of WPI's Center for Firesafety Studies, and George Jumper, an expert in heat transfer who spent 21 years as an aerospace researcher with the U.S. Air Force, are developing an experiment to answer this question. The experiment consists of four chambers in which intense lamps will heat small samples of a paper-like material. Sensors will monitor the heat absorbed by the samples and detect the exact moment when they begin to burn. The time-to-ignition in space will be compared to trials on Earth.

While the experiment will answer one important question in space-based fire safety, many others remain to be explored, Custer says. In 1986, NASA provided WPI's firesafety center with funds to conduct a feasibility study for additional research. In addition, the agency has funded studies on safety issues that corporations may perceive as barriers to the use of the U.S. space station. The study is being conducted by Custer and John M. Wilkes, associate professor of social science and policy studies.

In 1982, as the initial GASCAN program was beginning, space research was rare at WPI. Today, work related to space can be found in virtually every corner of the campus.

"It was clear in the early 1980s that WPI was at a point where it was appropriate to reemphasize scholarship and research," says Frank Lutz. "That meant that if our project program was to continue to have the full support of the faculty, it would have to provide opportunities to blend faculty research with the student projects the faculty would advise over the next decade or so. That is why the space shuttle program was so attractive."

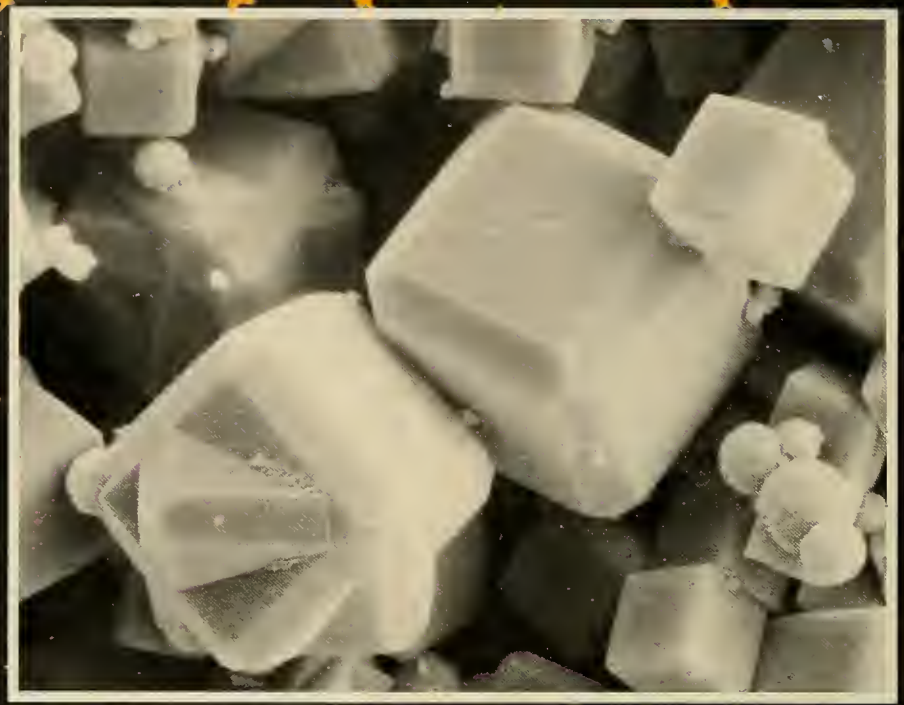
The program also provided insights into how to make student projects more useful to students. Ann Garvin, director of academic advising, says the program pointed out the value of having students make oral presentations about their projects.

All the students working on GASCAN projects were required to present their results to professionals at MITRE. In addition, small groups of students have presented their work at NASA/University Advanced Space Design Conferences.

The GASCAN and Advanced Space Design programs also seem to be producing a distinguished group of alumni, according to William Durgin. He notes that nearly all of the more than 300 students who have completed projects through these programs are now working in the aerospace field, completing military service in related areas or attending graduate school.

And, Durgin notes, the program has been an excellent tool for promoting cooperative research among faculty and students from diverse disciplines at WPI and has made the college more attractive for future faculty prospects. But, he says, the most enduring legacy of the space shuttle projects may be the many people at WPI and among its alumni who are now interested in exploring the world beyond the Earth's atmosphere.

"It was a marvelous foot in the door," he says. "And now, from that beginning, we have grown a whole new scholarly area at WPI. That's a real success story."



Growing Crystals in the Final Frontier

In a few years, a WPI experiment will soar into space aboard a sophisticated NASA space laboratory

Like many important stories in science, this one began in a small way, with two men, in a quiet moment, discussing an idea.

Early one evening in 1983, Albert Sacco Jr., professor of chemical engineering, and the late Leonard B. Sand shared a pizza and a few beers in a restaurant near the WPI campus. While a professor of chemical engineering at WPI, Sand had established an international reputation for his pioneering work on a group of crystalline compounds known as zeolites. On this evening he wanted to explore ways that he and Sacco could collaborate on scientific research.

"I had worked extensively on regenerative life support systems for NASA before coming to WPI," Sacco says, "but Len wanted me to get involved with zeolites. We decided to find a way to combine zeolites with space research. What we came up with was a series of student projects aimed at growing large zeolite crystals in orbit."

From that small beginning has grown one of the largest funded research programs currently under way at WPI—a program that will produce a zeolite growth experiment that will fly aboard the first United States Microgravity Laboratory (USML 1), a sophisticated space workshop that will ride into orbit in the cargo bay of a space shuttle in the early 1990s.

As a member of the Clarkson University Center for the Commercialization of Space and the Battelle Laboratories Center for the Commercial Development of Space, Sacco is working on the project with NASA and several chemical and aerospace corporations, as well as with Anthony G. Dixon, associate professor of chemical engineering, and Robert W. Thompson, professor of chemical engineering.

WPI is one of only two universities to

BY MICHAEL W. DORSEY

have experiments approved for the mission to date, Sacco notes.

"We have beaten out the competition, which includes some of the most prestigious schools in the country," Sacco says. "We are at the top of our game."

Zeolites are made primarily of aluminum, silicon and oxygen. These elements combine to form a crystalline structure that encloses a network of extremely uniform pores and channels. These pores make zeolites extremely selective sieves, separating, for example, the useful products of a chemical reaction from the raw materials and other by-products. When laced with other compounds, zeolites can make excellent catalysts and ion-exchangers. These properties have been employed in a wide variety of chemical processes, from cracking crude oil to softening water to making nonalcoholic wine.

While zeolites are found in nature, synthetic zeolites are preferred for most industrial applications because they can be custom-made for specific applications. By controlling the composition, concentration and temperature of the solutions used as feed stock for zeolites, one can produce crystals with precise pore sizes or with specific chemical activity.

But while scientists have been able to control some of the properties of zeolites, they have had less luck varying their size. The majority of the zeolite crystals produced in the laboratory are small—about two thousandths of a millimeter in width or smaller. Much larger crystals, could they be produced, might open the door to a variety of new applications for zeolites, including the treatment of chemical and radioactive wastes and the purification of the highly valuable products of biotechnology operations.

In fact, crystals hundreds of times larger than those commonly used by industry have been grown, but not in the laboratory and not by man.

"Very large zeolite crystals have been found in ancient salt beds," Sacco says. "These crystals grew very slowly, suspended in these beds, for millions of years."

Since scientists don't have the advantage of geologic time, they have had to cheat a bit, according to Thompson. To get crystals to grow in a reasonable amount of time in the laboratory, scientists employ highly-concentrated nutrient solutions. These supersaturated mixtures grow crystals readily, but there is a tradeoff.

Because the nutrient solutions are so dense, crystal growth tends to begin simultaneously at many points throughout the mixture. Before long, dozens of embryonic crystals are developing, rapidly consuming the dissolved chemicals. Compounding matters is the tendency of the zeolites to sink as they grow. As the crystals crowd together in the bottom of the reaction chamber, the nutrients are depleted and things grind to a halt before the crystals can grow to a respectable size.

Various techniques have been employed to overcome the limits on zeolite growth. While some have achieved moderate success, all have ultimately run up against the inexorable force of gravity. Since gravity is the culprit, the obvious solution is to grow zeolites in the absence of gravity. But to do that, one has to travel into space.

By a fortunate coincidence, as Sacco and Sand were mapping out their plans for a space-based research effort in zeolite growth, WPI's first Getaway Special Canister (GASCAN—see previous article) was just beginning to take shape. The two proposed their idea to the GASCAN technical steering committee and it became one of 12 experiments that would compete for space in the experimental package.

Over the next three years, teams of WPI students, working on their major qualifying projects (MQPs), took the zeolite crystal growth experiment from conception to flight-ready hardware. When the GASCAN finally flies into orbit later this year, the zeolite experiment will be aboard.

The design for the experiment is fairly simple. About two weeks prior to the shuttle launch, a mixture of silica and alumina will be poured into two Teflon containers arranged inside an aluminum autoclave. The autoclave will be placed in the GASCAN just before it is loaded in the shuttle cargo bay. Once in orbit, the autoclave will heat the mixture to a prescribed temperature and the growth of the zeolite crystals will begin. If all goes well, when the GASCAN is returned to Earth a few days later, the autoclave will be opened to reveal crystals of record size.

That is the hope, at least. Sacco says the design of the GASCAN experiment has an important drawback which may limit the size of the crystals it grows. Because the growth solutions must be mixed on Earth, crystal growth will begin when the mixture is still under the influence of gravity and its deleterious effects.

"This experiment is not perfect," Sacco says, "but the experience we gained from building it has given us a tremendous edge over other colleges in the design of hardware for crystal growth experiments in space."

Robert W. Thompson, professor of chemical engineering, holds a vial containing a mixture of alumina and silica. From this mixture grow zeolites, crystals used in a number of industrial applications. Thompson is part of a WPI team that hopes to grow unusually large zeolites in Earth orbit.

ROBERT S. ARNOLD

In fact, when NASA began looking for universities to participate in a new Center for Commercial Crystal Growth in Space in 1985, WPI's experience persuaded the agency that the college should be a member. When the center, headquartered at New York's Clarkson University, was assembled in 1986, WPI was one of five universities to be included. The others are Clarkson, the University of Florida, Rensselaer Polytechnic Institute and Alabama A&M University. Other participating organizations include 13 engineering and chemical corporations and the National Institute of Standards and Technology.

As a component of the new center, Sacco's team has received substantial funding from NASA—funding which currently runs at more than a quarter million dollars annually and is projected to rise to nearly a half million dollars next year. With those funds, Sacco, Dixon and Thompson are preparing a new space-based zeolite growth experiment. The new experimental package will be part of USML 1, a sophisticated array of experiments in basic and applied science that will fly in the cargo bay of the space shuttle. Similar in design to the Space Lab that has flown on previous shuttle missions, USML 1 is billed as America's answer to a perceived European and Soviet lead in space research, particularly basic research in materials processing.

"All of the science that goes into this project has to be A-number-1 top quality because we are putting this out as our best effort," Sacco says. "This mission has national and international implications."

The heart of the zeolite package for USML 1 will be a variable-temperature furnace in which up to 100 canisters filled with various zeolite growth mixtures will sit for several hours. To avoid the shortcomings of the GASCAN experiment, astronauts will mix the growth solutions after the shuttle is in orbit. Between four and eight hours of astronaut time will be set aside for this task, Sacco says.

Before the package can actually be constructed, some tricky hurdles must be overcome. For example, how can an astronaut "pour" zeolite solutions into 100 vials in the absence of gravity, and without any potentially dangerous spills, in the relatively short amount of time set aside for this job? Will the solutions mix properly in zero-gravity? And, how will the vibrations caused by the movement of astronauts—a phenomenon known as G-jitter—affect the growth of the crystals?

One of the greatest challenges will be the design of the furnace. While the Soviet and European space agencies have flown temperature-controlled furnaces in space, the unit designed by the WPI team will be the first such unit ever carried on a U.S. space mission. The design of the device is the responsibility of Dixon.

"The furnace will be made up of many small zeolite reactors packed into an insulated chamber and surrounded by heating coils," Dixon notes. "We'd like to develop a strategy where we can have precise temperatures in various areas of the furnace so each type of zeolite can grow under optimum conditions. We have to accomplish this with some very strict power constraints."

Before a prototype of the furnace is ever built, Dixon will use a computer to create a model of the device. With the computer model, Dixon will determine how heat will be distributed through the chamber and will determine how to make the most efficient use of the furnace's heating coils. After a successful prototype is fabricated at WPI, the actual, flight-ready device will be built by an aerospace contractor such as Rockwell International Corp. Either the Battelle Laboratories Center for the Commercial Development of Space or the Clarkson Center will oversee the management of the WPI project, a task that includes filling out more than 40 pounds of NASA documentation.

While designing the hardware for the experiment will pose some daunting challenges, some fundamental questions must also be answered before the experiment can fly. For example, how will a three-phase solution behave in space?

Most substances can exist in three distinct phases—solid, liquid and gas. When zeolite growth solutions are mixed, they form a fourth phase called a gel, which is not quite a liquid, but also not quite a solid. As the crystals begin to form, there are three separate phases in the growth mixture—the clear liquid of the original solutions, the gel and the solid crystals themselves. Although its role is not entirely understood, gravity certainly helps determine what results from this three-phase system on Earth. The question that

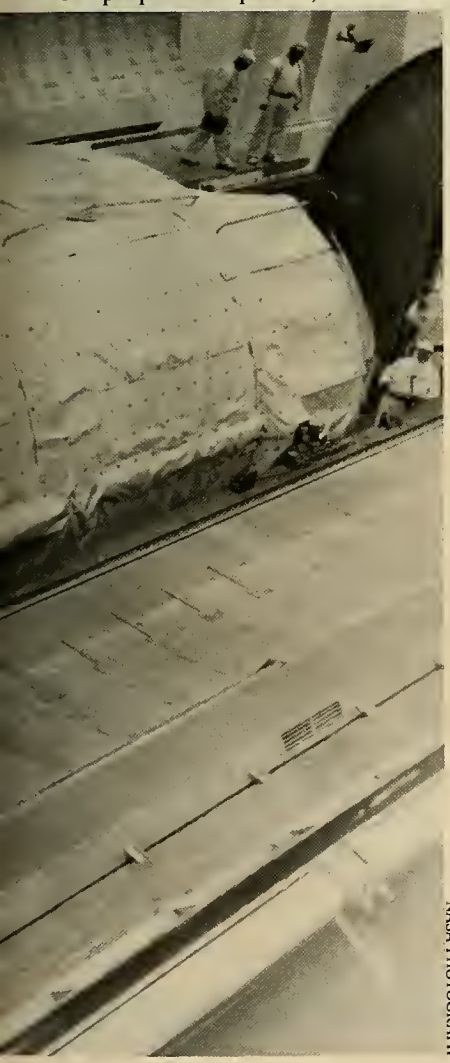
WPI's zeolite growth experiment will fly aboard USML 1, a space laboratory similar to the European Space Agency's Space Lab, seen here in the cargo bay of a space shuttle. The lab will be launched in the early 1990s.

Dixon, Thompson and Sacco must answer is what will happen without gravity?

To do that one must first understand what really takes place as the zeolite growth solution performs its magic. Though scientists and engineers have been experimenting with zeolite growth for several decades, surprisingly little is known about what happens between the time the alumina and silica solutions are mixed and the moment the crystals appear, according to Dixon.

In the months ahead, Dixon, Sacco and Thompson, leading teams of postdoctoral students, graduate students and undergraduates working on MQPs, will begin to study the fluid dynamics and chemistry of zeolite formation, answering questions that no one has needed to ask until now. The results of this work may, Dixon notes, have consequences far more profound than the growth of champion-sized crystals in space.

"The need to go into space is providing the motivation to move away from the sort of black art we've practiced here on Earth, where people have poured, stirred and heated," Dixon says.



NASA PHOTOGRAPH

The WPI experiment will include the first temperature-controlled furnace to fly on a U.S. spacecraft. Anthony Dixon, associate professor of chemical engineering, is developing a computer model of the new furnace.

ROBERT S. ARNOLD

"They've had little reason to do otherwise because it's worked. Going into the environment of space has opened up a host of processing questions. We are taking the lead in answering them."

"Even if we never grow a large zeolite crystal in space," Sacco adds, "we will not have failed."

To find out more about what happens to zeolite solutions without gravity, preliminary experiments will be conducted by Sacco aboard one of NASA's KC-135s, converted Boeing 707s that fly roller-coaster-like paths across the sky. On the downward portion of each parabolic arc, the plane and its contents experience about 30 seconds of zero-G. Additional tests may be conducted in a drop tower at NASA's Lewis Research Center in Cleveland, which can provide a few seconds of weightlessness.

In addition to the basic research that will lay the foundation for the USML 1 experiment, the WPI team must design the flight hardware, supervise its construction, train the shuttle crew that will carry out the work in orbit and, in about three years, travel to NASA to monitor the progress of the experiment itself. For nine days, Sacco, Dixon and Thompson, working in eight-hour shifts, will man a console at the Johnson Space Center in Houston while the shuttle orbits overhead.

For the WPI team, the months now seem to stretch before them in a seemingly endless series of timelines and milestones, Sacco notes. A missed deadline could easily bump the WPI experiment from the USML 1 manifest. But, even though their efforts are currently focused on preparing for USML 1, Sacco, Thompson and Dixon are already beginning to turn their thoughts to future work—to continuing the space-based study of zeolites after USML 1 returns to Earth.

Already, the Boeing Company, which will design and build the material processing laboratory for the U.S. space station Freedom, has consulted Sacco's group about the requirements for conducting zeolite growth research aboard the future space platform. That's a sign, Sacco says, of the long-term interest in this line of work on the part of NASA and U.S. industry. Sacco said both the European Space Agency and scientists from the Soviet Union also have expressed an interest in their work.

"The President's Commission on Space said that chemical engineers are one of the key groups that will be needed for the commercial development of space," Sacco notes, "because the exploitation of space will require new ways of processing natural materials. I feel confident that zeolites will be one of the important materials that find a long-term home in space. If that happens, WPI will be right up there with the most active research groups in the U.S., thanks in large measure to that original vision of Len Sand."

From Lindbergh to Sputnik

The story of "K." Merriam and WPI's first aero program

In May 1927, an obscure flyer named Charles A. Lindbergh completed the first solo flight across the Atlantic Ocean and brought the world into the Air Age. The implications of this milestone were clearly recognized by WPI's sixth president, Admiral Ralph Earle.

At Earle's request, Kenneth G. Merriam, one of the youngest professors then at WPI, developed a program in aeromechanics, which he would teach for more than three decades. Before accepting the assignment, Merriam set conditions which remained throughout the life of the program. It was to be taught as a senior mechanical engineering option with admission limited to top students.

To Merriam's surprise, Earle agreed to his conditions. The first class began in 1928, a year after Lindbergh's flight.

With the inauguration of the aero program, Merriam was promoted to assistant professor. Then, signifying the expectations President Earle had for the program, he named Merriam to the newly established Elmer P. Howe Distinguished Professorship. This was only the second faculty chair at WPI, the first having been established in 1915 by Prof. John E. Sinclair. At the end of his career, Merriam would enjoy the unique distinction of becoming the only WPI professor both to hold an endowed chair and have one named in his own honor.

Merriam was born and raised in Belfast, Maine. When he graduated from MIT in 1922, he accepted an instructorship at the University of Maine, but left to join the mechanical engineering faculty of WPI just a year later. This was the beginning of a 46-year career for a man regarded by many former students as one of their greatest teachers.

Merriam described himself as a demanding teacher, though this quality would not have distinguished him from most of his colleagues. What endeared him to his students was his concern for them and the family spirit he developed with students in the aero program. In the early years, he

BY ROGER N. PERRY JR.

and the new class of "Aeros" would start the year with a climb up Mount Monadnock in New Hampshire. After World War II, the tradition was changed to a less strenuous evening at the Boston Pops.

The class met on the top floor of the Washburn Shops, which Merriam had converted to a combination classroom and laboratory. Prominently located in the middle of the floor was a full-sized, fabric-covered U.S. Navy monoplane with a 52-foot wingspan. (Getting the plane into the building had proved no mean feat.)

Here and there were aircraft engines, some working and some cut-away specimens. The walls were decorated with propellers and photographs of vintage airplanes and early aero classes. The laboratory included WPI's first wind tunnel (developed by Merriam's students), in which Merriam himself did pioneering work on Pitot tubes—used to measure the speed of aircraft.

Each student was required to conduct research on some aspect of aeromechanics and prepare a thesis, even after the thesis requirements had been dropped for other WPI seniors. During the 1930s, there was a special realism to the program as students enjoyed hands-on experience with aircraft at the Grafton Airport, where Merriam had developed a close relationship with the staff. During this period, many students earned their pilot's licenses at the airfield, which served Worcester until the present city airport was constructed at the end of World War II.

In those early days, the young, red-haired professor was often referred to by his students as "Pinky." With more maturity, he became known by the nickname "K.G." In the latter years of his teaching career, faculty colleagues and students alike knew him simply as "K."

K. Merriam, who was commissioned as an officer in the Army Reserve at graduation from MIT, was called to active service during World War II. His specialty was anti-aircraft artillery and by war's end he was director of fire control for all anti-aircraft weapons. He was discharged in 1946 with the rank of colonel.

During the war years, the aero program continued under the direction of Frank Finlayson '31, one of the program's first graduates. Finlayson and several other faculty members shared the teaching load with Merriam through the years.

The aeromechanics option, which began with the birth of the Air Age, ended as the Space Age dawned. The last aero class graduated in 1959, less than two years after the Soviet Union launched the world's first satellite, Sputnik I, and a little over a year after the U.S. sent its first satellite, Explorer I, into orbit.

Merriam received the Trustees' Award for Outstanding Teaching in 1961. Three years later, WPI conferred on him an honorary Doctor of Engineering degree.

After he retired in 1969, Merriam donated to the WPI archives the scrapbooks in which he had carefully chronicled the aero program. Reading through these hundreds of pages shows why he was so special to his students. Included are the annual letters he sent to graduates apprising them of the status of the program and of the professional progress of each alumnus.

His snapshots of students in the lab and at Grafton Airport form a pictorial record of the program. A note on one page mentions that cigarette smoking was not permitted in the lab, it being a fire hazard. Yet pipe-smoking students appear in many pictures. Merriam himself was a confirmed pipe smoker. There are also photos of the gliders Merriam and his students built, licensed and flew in the early days of the program.

The scrapbooks include copies of correspondence with Robert Goddard '08, indicating a mutual respect for each other's work. Goddard, for example, asked Merriam to supervise the work of one of his graduate students at Clark University while Goddard was conducting research in New Mexico. When he was in Worcester, Goddard was a frequent visitor to the top floor of Washburn Shops.

Merriam also proudly included in these pages newspaper clippings that chronicled the careers of aero alumni. They tell, for example, of Arthur Smith '33, Richard Whitcomb '43 and other aviation pioneers (see sidebar). But Merriam was just as proud of each of his other graduates.

In one of the scrapbook's last pages, Merriam summarized the aero program through its 30 years. He personally taught 244 students in 27 classes. Of these, 40 percent graduated with distinction. He noted, for example, that according to the 1963 issue of the *Alumni Directory,* half of his Class of 1929 students were working in the field of aviation.

At Reunion in 1977, WPI President George Hazzard announced that one of Merriam's former students had established an endowed professorship in his name in grateful recognition of the inspiration he had given to his students throughout his 46 years on the WPI faculty.

A few months later, Merriam was invited to a ceremony in Higgins Laboratories at which the first Kenneth G. Merriam Distinguished Professor was announced. Merriam was especially pleased with the selection of Raymond R. Hagglund '56, who had been both his student and faculty colleague.

Four days later, Merriam died suddenly at the age of 75.

Perry is editor of Quest, *a periodical reporting on the* Campaign for Excellence.

The late Kenneth G. Merriam (left) and some of his early "Aeros."

An Honor Roll of Aeronautics Pioneers

Some of the most important advances in modern aviation were forged by WPI graduates.

Robert Goddard '08 may be the most famous aerospace pioneer to have graduated from WPI, but he is certainly not the only one. Here are some other WPI alumni who changed the face of aviation:

Arthur Nutt '16, one of the greatest authorities on aircraft engines in his day, developed the first successful engine to produce 350 horsepower. He was later able to more than double the power of Wright Aeronautical Corporation engines without increasing their weight. In the 1950s, at the Lycoming Division of AVCO, he oversaw the production of Wright's Cyclone engines, which powered 90 percent of commercial aircraft of the day. In 1978 he was inducted into the Aviation Pioneers Hall of Fame.

An early graduate of WPI's aero option, **Arthur E. Smith '33** spent most of his career at United Aircraft (which later became United Technologies), becoming its president in 1968 and chairman in 1972. As an engineer at United Aircraft, he did pioneering work on the use of water injection to increase the power of aircraft engines, work that contributed to the success of U.S. aircraft during World War II. Smith later played an important role in United Aircraft's transition into the Jet Age.

Another of Kenneth Merriam's students, **Eugene Larrabee '42,** conducted pioneering research on low-speed aerodynamics at MIT. The work played a direct role in the successes of the series of human-powered Gossamer aircraft designed by Paul MacCready, who holds an honorary doctorate from WPI.

Another of WPI's distinguished graduates, **Richard T. Whitcomb '43,** also studied under Kenneth Merriam. After receiving his B.S. degree, Whitcomb joined the National Advisory Committee for Aeronautics (which later became NASA). Working in the transonic wind tunnel at the Langley Research Center in Virginia, Whitcomb set out to learn why airplanes experienced more drag than conventional theory predicted they should when flying at transonic speeds (speeds greater than the speed of sound).

In December 1951, while puzzling over photos taken of models in the wind tunnel, he made an important discovery, which he called the Area Rule. Drag at high speeds, the rule says, is a function of an airplane's total cross-sectional area (essentially the thickness of the fuselage). Because projections from the fuselage increase cross-sectional area, Whitcomb reasoned, narrowing the fuselage at the point where the wings and tail assembly attach should reduce both cross-sectional area and drag.

Arthur E. Smith '33 (above), former chairman of United Aircraft, and Richard T. Whitcomb '43 (right), who discovered the Area Rule.

NATIONAL AIR AND SPACE MUSEUM

He tested a model with a pinched-waist design and found that it behaved exactly as he had predicted. The model is now in the Smithsonian's National Air and Space Museum. The idea was soon tested on a full-sized airplane, the Convair YF-102, a new delta-winged jet fighter that had not performed well at transonic speeds. The plane was lengthened and given the now-famous "Coke-bottle" fuselage. It "slipped right past the sound barrier and kept on going," its test pilot reported.

In the 1960s, Whitcomb developed the supercritical wing for NASA. With a blunted leading edge, a flattened top and a trailing edge that curved downward, the wing delayed the onset of shock waves that normally appear on the upper portion of the wings of aircraft flying near the speed of sound. The wing allowed commercial jetliners to fly faster and more efficiently.

Whitcomb's achievements, widely regarded as among the most important in the history of modern aeronautics, have earned him numerous honors, including the Collier Trophy, aviation's highest award, bestowed in 1954 in honor of his development of the Area Rule.

—Michael Dorsey

Ode to the '80s

A Limerick Contest for Our Readers

How permissive we are in the Eighties!
And how free are the gents and the ladies!
But how can we be sure
If our hearts are not pure
That we won't end our journey in Hades.

—Isaac Asimov

Isaac Asimov's limerick sets the pace for our contest. Light verse is a source of pleasure for the renowned writer of science fiction and science fact. Of his 405 books, "seven are of limericks—and two of those are clean," he notes.

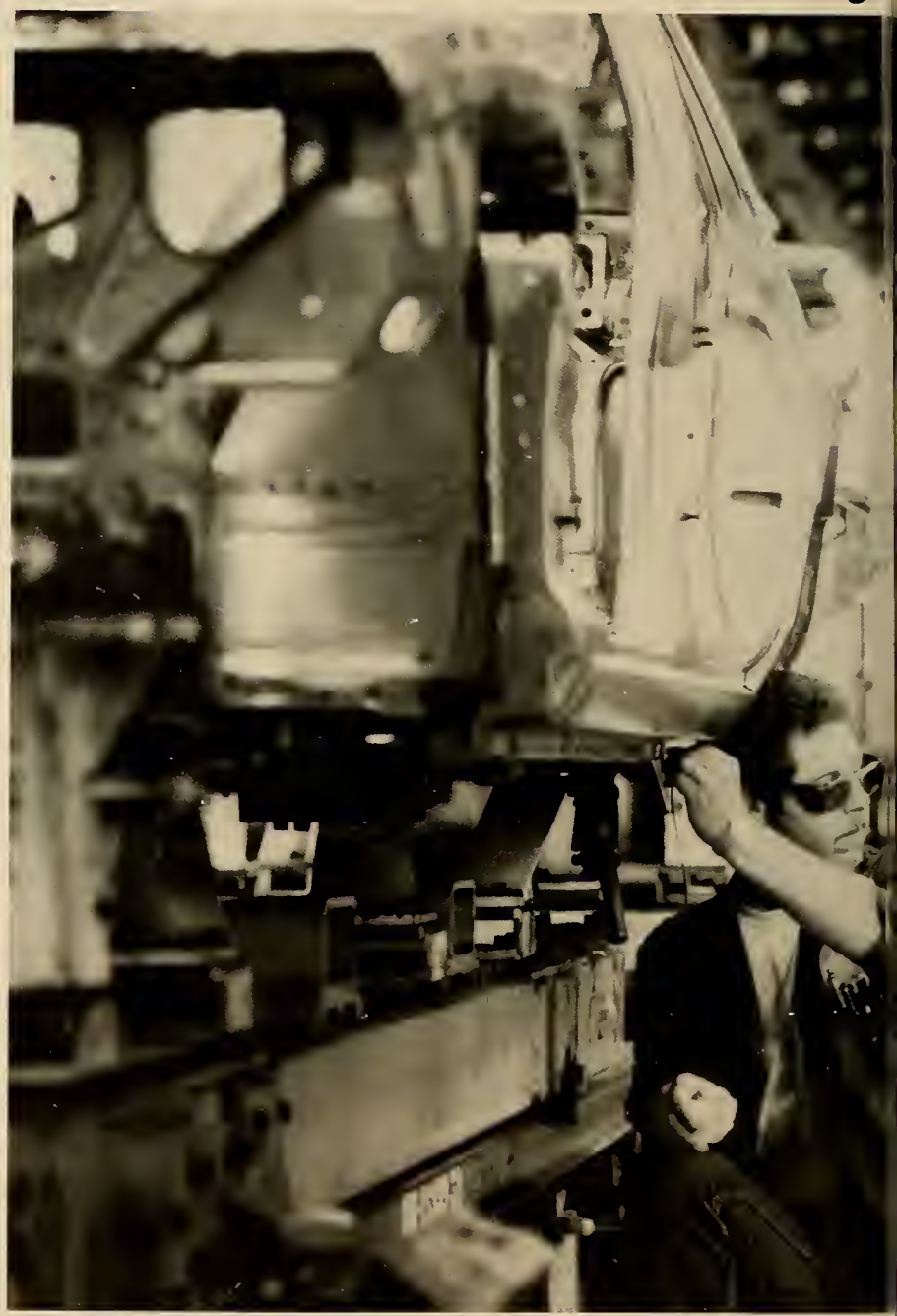
As we turn the corner to the next decade, how would you capture—in five lines—the mood of the past 10 years? For each limerick we publish in the August issue, we'll pay $100. The grand prize winner will also receive a framed copy of the winning limerick and the original artwork illustrating it. Please send your entry by May 1 to the magazine editor. Questions? Call (301) 338-7904.

ILLUSTRATION BY TRISH DINKEL CROWE

The Smart Assembly

To compete in the world marketplace, American industries will use high-tech sensors to find and correct product flaws—before it's too late.

By Sue De Pasquale



Ultrasonic weld testers help workers on automobile assembly lines to increase speed and reduce scrap. The CRT screen displays the results in wave forms that they can easily understand.

By the time a can of salmon finds its way to your supermarket shelf, it has probably traveled thousands of miles. The cans are usually made in a Southern plant, flattened, and then sent to the Alaskan Northwest, where they are re-formed, filled with freshly caught fish, sealed, and shipped off. Since the tiniest leak would allow air to enter, with the potential of causing botulism, the salmon packer needs a fast, efficient method to test if every can is sealed.

One new test is so precise that it could virtually eliminate the possibility of a "leaker" finding its way to your shelf. The package is placed in a sealed test chamber, and a minute amount of pressure (less than you could blow with your mouth) is applied externally to its lid, causing it to deflect inward. If there's a leak, air will gradually seep in and the lid will relax back to its original position. If

COURTESY BAROLIN ADVERTISING

the package is airtight, the lid will remain slightly concave.

Since the typical lid moves less than a thousandth of a millimeter, the contents aren't affected by the test at all, explains James Wagner, the Johns Hopkins University materials scientist who developed the technique. To do so, he drew on advances in nondestructive evaluation (NDE), a way of testing without taking things apart.

Wagner shines a laser beam on the test object and creates an image that passes through a holographic filter. The light leaving the filter dims as the lid deflects in, and grows brighter when the lid relaxes. By measuring the time between dimming and brightening, he can determine the magnitude of the leak: two seconds for a bad leak, a full minute for a very small one.

Campbell's Soup officials have already asked about using the process, Wagner says. In addition to testing cans, the technique can be used to find the most minuscule leaks in pacemakers and microelectronic circuits—and even the space station. (See page VI for how the laser works.)

Wagner explains the nature of NDE testing by picking up the flexible nameplate on his desk. "You could put this in a jig and break it to find out where it is weakest," he says, bending the piece of plastic back and forth. "Or you could bend it until it's about to break to find out. But both times, you'd destroy or damage the material," and that's exactly what the researcher for Hopkins's Center for Nondestructive Evaluation (CNDE) hopes to avoid.

Instead, he and colleagues in the emerging field of NDE rely on noncontact advanced sensors—which use lasers, magnetic fields, and ultrasound techniques, among others—to examine and characterize materials without touching them or breaking them down. Installing these advanced sensors on American production lines could transform manufacturing by cutting labor and production costs and by improving quality, advocates say.

During the late 1960s and '70s, noncontact methods like X-rays and lasers were used mostly to locate flaws in structures after they were in use. "The emphasis of NDE in the past has been life management," explains Wagner. "How much longer can a bridge last? How much longer can a plane fly? How much longer will the rubber last on tires?"

Today the push is toward characterizing the materials themselves—the molecular make-up of a polymer fiber or the internal temperature of an ingot of steel—at each stage of production. That allows manufacturers to predict, and ideally, to correct, missteps on the assembly line before large batches of flawed materials get by.

In effect, NDE technology is making it possible to test the manufacturing proc-

ess itself, rather than simply the product, explains Yoh-Han Pao, director of the Center for Intelligent Systems at Case Western Reserve University.

Since the early 1980s, many NDE techniques have made the transition from the research lab to the industrial test site. Makers of computer disk drives rely on images created by laser holography to see how drives change shape as they run and heat up. Naval contractors can predict the strength of rope by examining its electrons through a technique called paramagnetic resonance imaging. Quality controllers use ultrasonic imaging to check for defects in nuclear reactor fuel rods.

"Since the sensors examine things from a distance, NDE techniques are particularly well-suited for components that are small and fragile—as in microelectronics—and for testing objects in hostile environments with temperatures of a few thousand degrees," explains Ryzard Pryputniewicz, director of the Center for Holographic Studies and Laser Technology at Worcester Polytechnic Institute (WPI).

Traditionally, quality control testing has been done manually (and often, destructively) at the end of the manufacturing process to separate acceptable products from unacceptable ones. "You could test every 20th product coming out and reject the ones that weren't good. That allowed bad products to get by," Wagner explains. "If you don't test every product coming out, there is statistical room for error. That's not O.K. for space shuttles, and aircraft, and heart valves."

There's also a financial interest at stake, since problems aren't discovered until large amounts of time, energy, and money have already been invested. If a sample of steel is found to have the wrong consistency, the whole batch has to be scrapped. If a weld on an automobile fender is defective, it has to be ground out and redone.

In today's high-tech industries like aerospace and microelectronics, where materials are becoming increasingly exotic, the cost of rejecting completed products is prohibitive, says Moshe Rosen, chair of materials science at Hopkins.

He cites carbon-carbon composite material as an example. What starts out as a cloth of carbon fibers goes through a series of "master chef" manufacturing processes. The fibers are steam cooked, pummeled, then compressed, until they emerge lighter and stronger than steel and able to withstand temperatures exceeding 3,000 Celcius. Ideal for use in jet engines and turbines, a block of carbon-carbon composite the size of a shoebox would cost as much as a house.

"Imagine that you finish this product—which should supposedly be worth $100,000—and in testing it you find it's just a piece of junk, full of porosity, with a final density that's not acceptable," says Rosen. The flawed composite would either have to be thrown out or recycled at tremendous expense.

Using NDE techniques to test it at each stage of its production would greatly reduce the possibility of a costly surprise at the end, Rosen explains. That's the idea behind intelligent manufacturing, or in-process control, says Robert Green, director of the CNDE at Hopkins.

"It's both practical and cost effective to expand the role of NDE to introduce it much earlier in the manufacturing cycle," he says. "In fact, the recovery of a large portion of U.S. industry from severe economic problems is dependent, in part, on the successful implementation of this expanded role for NDE."

The steel industry has been slowest to turn to NDE techniques, according to Thomas Yolken, chief of the Office of NDE for the National Institute of Standards and Technology. "In the area of steelmaking, we're behind the Japanese, the French, and the Germans. But in advanced materials—composites and ceramics—I think we're ahead," he says.

"In the United States, we've always had a very good base in materials science. What we've been lacking in is moving that research into manufacturing. If we must produce materials in large quantities at high quality and reduced cost, that means automating—intelligent processing," Yolken believes.

Take, for example, the case of the ultrasonic weld-tester being used on some American automobile assembly lines. In the past, automakers had to pull sample auto chassis from the assembly line and then chisel apart spot welds to see if they had bonded. Today, plant workers can tune in to portable, battery-operated ultrasonic analyzers. In the same way a doctor places a stethoscope on your heart, an autoworker places a transducer on the dime-sized welds found in fenders and engines.

The transducer sends out an ultrasonic sound wave that penetrates the weld and sends back an echoing signal. The analyzer interprets the echo and displays the results on a CRT screen wheeled around by the technician. The worker knows what to look for: A good weld will send back a train of double-spaced echoes that get progressively shorter; a weld that didn't take will send back a train of long waves set very close together.

Since these ultrasonic spot tests can

Reinhold Ludwig (above) at WPI developed a computer model that aids engineers in evaluating nuclear reactor flaws. Top right: To find out why a glaze has worn away from a tile, Jane Maclachlan Spicer and John Murphy at Hopkins turn to nondestructive evaluation. In another use of it, James Wagner (right) at Hopkins holds a test chamber that contains a microelectronics package.

Sue De Pasquale is assistant editor of the Alumni Magazine Consortium.

PETER HOWARD

PETER HOWARD

be done so quickly, workers are able to check many more welds than before. And they can reprogram a robotic spot-welder that has begun to deviate from its specifications—before an entire line of bad welds is made. The analyzers cut labor costs, reduce scrap, and ensure the quality of those welds found in hard-to-reach spots.

Engineers at the Martin Marietta Aerospace plant in Baltimore found similar advantages when inspecting graphite-epoxy composite, a material used in the wings of military aircraft. "By using the method of ultrasonic testing, you are able to evaluate every square inch of the part for its bonding integrity," says Richard Lee, director of quality for Martin Marietta. "If you didn't use it, you'd have to utilize a labor-intensive manual method."

Most experts agree that NDE technology will play a pivotal role in the future of this country's aerospace programs. The aerospace plane, the space station, and structures related to the Strategic Defense Initiative will use a wide array of new materials that must stand up under fiery temperatures and intense atmospheric pressure changes. Ensuring that protective coatings do not peel away from these materials will be crucial, says Jane Maclachlan Spicer, a researcher at the Hopkins Applied Physics Laboratory (APL).

She and colleague John Murphy are using a thermal imaging method to study how ceramic coatings can bond most effectively with the materials (substrates) they're intended to protect. Right now they're faced with a challenge posed by New York City's Holland Tunnel. On some of the ceramic tiles lining the tunnel's interior, the glaze has worn off, making the rough surfaces a magnet for blackening diesel exhaust. Tunnel officials are concerned about the odor and fumes generated by the sooty build-up. The APL team will employ time resolved infrared radiometry to help inspectors evaluate which glazes will stand up best.

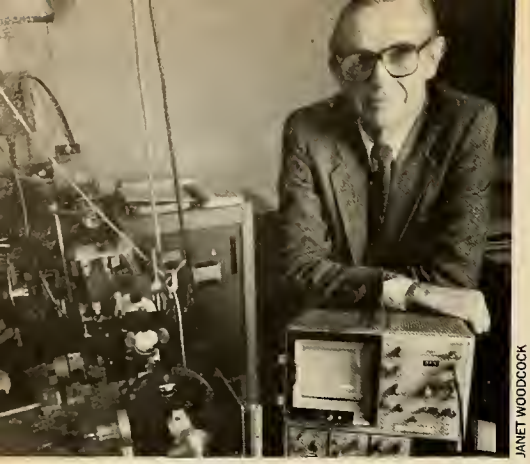
Their technique has other testing applications as well: from the thin ceramic films on integrated circuits to the protective tiles used on the space shuttle.

The researchers aim an argon laser at the ceramic/substrate sample they're testing, and then heat the sample by pulsing the laser on and off. An infrared scanner tracks the sample's surface temperature as a function of time and produces a "false color" image. (They've assigned colors using numerical values to represent the varying temperatures.) Globs of blue and green typically show where the coating adheres well; oranges and yellows tip them off to regions where the bonding hasn't held.

Conventional thermal imaging methods can be very time consuming, since the tester must individually examine each pinpoint on the test sample. But this new technique allows Murphy and Maclachlan Spicer to broaden their laser beam to evaluate hundreds of points at one time. The result is a far speedier inspection, Murphy says. That factor makes the NDE technique a natural for use on production lines.

Thermal imaging could be used early

continued on page VIII.



JANET WOODCOCK

How a laser harnesses the energy of light

By Leslie Brunetta

The laser has become one of the most versatile tools known to science, industry, communications, and medicine. The same physical principles that enable one laser to slice through heavy-gauge steel and another to measure the tiniest leak in a can also make possible the etching of intricate circuits on computer chips. Thus smaller and smaller computers can perform larger and larger tasks.

Lasers read bar codes, letting shoppers zip (they hope) through supermarket check-outs. Some lasers scan CDs, rendering Mozart and Motown cleaner and crisper; other lasers destroy tanks in military experiments. In medicine, lasers are replacing scalpels in many surgical procedures, while in communications, laser-based fiber-optic systems are making electronic telephone cables obsolete in intercontinental calls. Lasers have also become one of the chief workhorses in nondestructive evaluation, a technology that requires the ability to explore objects without cutting, burning, or in any other way affecting delicate contents or parts. What makes all this possible is the laser's unique ability to harness the power of light.

It all started with Einstein. Adding to earlier quantum theory, he postulated that atoms jump back and forth between fixed energy levels. In moving from a lower to a higher, or excited, level, the atom absorbs energy. When it moves back to the lower level, the atom radiates a photon (a tiny parcel of light energy). Moreover, Einstein theorized, if a photon of the right energy were to hit an excited atom, the atom would radiate a photon of equal energy. If these two photons were to meet two more atoms, two more identical photons would be emitted, and this doubling could continue indefinitely if there were enough excited atoms. What you would end up with is the effect produced by the laser—Light Amplification by Stimulated Emission of Radiation.

But not until 1960 did anyone figure out how to turn Einstein's idea into a machine. An American physicist, Theodore Maiman, took a small cube of synthetic ruby and mirror-finished both ends.

WPI's Donald Nelson (far left) built an early laser. CWRU's Alex Dybbs (left) uses lasers to measure gas flows.

When he shone an intense flash lamp on the ruby, the chromium atoms absorbed energy from the lamp, jumped to their excited energy level, and then started falling back, radiating photons. Every photon traveling perpendicular to the mirrors started zinging back and forth between the two, all the while colliding with other excited chromium atoms and causing more photos to be emitted.

Shortly after Maiman's announcement, a Bell Laboratories team headed by Donald F. Nelson, now a professor of physics at Worcester Polytechnic Institute, built a laser around a ruby bar about two inches long. His team became the first to observe pulses in the laser's beam. These pulses, created when more photons were produced than were lost to scattering, indicated that the laser threshold had been exceeded.

Thus in a fraction of a second, a short, powerful beam of deep-red light emerged through one of the laser's mirrors, which Nelson's team had only partially silvered. The laser had amplified the flash lamp's light to a power four times more intense than light at the sun's surface. (The intensity of light is the number of photons emitted per second per unit area.) But what made the laser light different from all other types was that—because the radiated photons were identical to each other—it had a single wavelength, or in other words, was monochromatic. And it was highly coherent, meaning it could travel great distances without diverging very much. Nelson's team was the first to measure this coherence. Later, working with a fellow Bell Labs researcher, Nelson also built the first continuously operating laser.

At this point, researchers weren't too concerned about finding applications for the laser. But its unique abilities soon got scientists thinking about their new-found power to manipulate light energy. They began to develop new lasers by substituting different media—for instance argon or carbon dioxide gases—for the ruby bar. Because the atomic structure of each laser medium is different, each produces a beam of a different wavelength. Laser scientists now have an arsenal of different lasers, some emitting a coherent beam of unique, predictable wavelength and others that can even be tuned.

One of the earliest, and most innovative, uses made of lasers was holography, which is especially valuable for NDE. To create a three-dimensional hologram, a laser beam is split in two by a semitransparent mirror. One beam then travels on to light an object, say an aircraft engine turbine blade. The light reflected from the blade strikes a photographic plate (or other detector). At the same time, mirrors direct the other beam onto the same plate. The plate thus records the pattern of interference produced as the now-differing wave patterns of the two beams combine with each other. When lit from behind by coherent light, this pattern of interference looks to the human eye like an exact, three-dimensional replica of the turbine blade.

Now, say a factory is producing a shipment of these blades, all from the same mold. The technician knows the first one produced is perfect, and makes a hologram of it. Leaving the device set up as is, with the original hologram in place, the technician simply replaces the first blade with another from the batch and turns on the hologram lasers. If this second blade in any way varies from the first, it will scatter the laser's light differently, and straight or curvy bands of light and dark will appear on the hologram, indicating precisely any flaws in the second blade.

This process can be used to a variety of ends, among them monitoring changes in computer disk drives during use, finding stress fractures in airplane parts, and checking wear patterns on tires.

Those coherent beams and single wavelengths of lasers also make them useful tools for assessing surface properties. Materials absorb or reflect a particular laser beam's light differently. For instance, a laser emitting a red beam can burst a blue balloon inflated within a white balloon while the white balloon remains undamaged, even though the laser beam is passing through it. The blue balloon absorbs red light much more efficiently than the white one, and therefore a hole is burned in it long before the white balloon even heats up.

Knowing this, researchers wanting to test, for instance, how well different glazes bond to ceramic tiles will choose the laser that can most efficiently supply exact measures of light energy directly to a tile's glaze. Because they can control the laser's pulses so precisely, they know they are delivering the same amount of energy to each point on the tile; they would never have such control if the glaze were heated in another way, such as with a flash lamp.

If, at a certain spot, the glaze has bonded properly, the heat delivered by the laser will conduct back through the ceramic tile and the spot will appear cool on an infrared detector; if the glaze hasn't bonded, heat will remain in the glaze and the spot will appear hot—a clear sign of trouble. The only way the researchers can rely on a readout showing that one spot is hot and another cool is if they know for sure that both spots were originally heated to the same degree. It's a measure of security that the laser's predictable beam can easily give.

Lasers are coming to the rescue in many other ways useful to industry. Alex Dybbs, co-director of the Case Center for Complex Flow Measurement at Case Western Reserve University, uses helium-neon, argon ion, and copper vapor lasers to measure the velocity of gas flows in and around airplane turbine engines. His technique, which doesn't disturb the flow, can be used for any flow, from air around a missile to blood through an artificial heart. Says Dybbs, "This type of measurement was impossible without the laser."

In a nice closing of the circle, the laser is now also used to verify many of the quantum theories proposed by Einstein and others, the very theories that first made the laser possible. For example, Henk Arnoldus, assistant professor of physics at Villanova University, predicts what will happen to atoms—how their protons, neutrons, electrons, and photons will act—when they are energized by the lasers' photons. "I do the theory," Arnoldus says, "and then I compare notes with someone who does the experimental work with lasers to see if we understand the atom's structure and function." Researchers now have so much control over the laser's workings that they can measure atomic processes taking place in as little time as one million-billionth of a second.□

A Boston-based writer, Leslie Brunetta formerly was assistant editor of the Alumni Magazine Consortium. Her last article for the Consortium was about the future of higher education.

continued from page VI.

in the manufacturing process to monitor a substrate's temperature—a critical factor in determining whether a coating will stick. It could be used further along in the process to control how evenly the coating is being deposited. And at the end of the assembly line, it would help to ensure that the part is acceptable and that its protective coating won't peel away.

"We're not only finding the trouble spots, we're using measurements to quantify a solution," Murphy underscores. His statement reflects a common aim among NDE engineers today. In addition to detecting and correcting flaws on the production line, they want to take the process one step further: They're working to replace the human operator with an artificial intelligence system—a computer with a knowledge base that enables it to interpret sensor information and then automatically adjust the proper controls.

"It actually learns from its own experiences, and can adjust future runs of the process based on this learning," explains Yolken.

The ideal intelligent manufacturing process involves interaction among three systems, each connected to the one before it. First, advanced NDE sensors monitor the material at various stages on the production line. Second, expert systems then use artificial intelligence to interpret the data generated by the sensors and automatically make adjustments. Finally, the process control mechanisms themselves (such as valves, pumps, and motors) regulate the temperatures, pressures, and velocities.

For instance, suppose the NDE sensors show that the consistency of a batch of steel is wrong at the end of stage two of its production. The computerized expert system would first recognize the problem, then figure out how to correct it farther down the line—perhaps by re-adjusting the temperature controls in stage three. The finished steel comes out intact, the production line never has to be shut down, and the stage two problem is also fixed so that the next batch can be processed correctly.

Since each stage of production compensates for the one before it, manufacturers can avoid setting unnecessarily high (and expensive) standards for any one stage. Says CWRU's Pao, "It's easy to say everything has to be perfect, but that's not always necessary. In process control, as in life, things compensate. There are no hard and fast criteria."

Explains Wagner: "The purpose is to manufacture in quality rather than to weed out the losers. When the process drifts out of control, the fully automated intelligent manufacturing process corrects it."

In most industries, such a system using artificial intelligence is still many years down the line. It's enormously difficult to program a computer with the knowledge base that will allow it to reason as humans do, emphasizes Robert Breece, director of research and development for Applied Optics, in Kensington, Maryland.

His contact lens manufacturing firm is trying to develop an artificial intelligence system that can distinguish between a "good" lens surface and a "bad" one. By running a delicate stylus over the surface of a lens they know to be right, Applied Optics researchers are working to define and quantify qualities such as roughness, smoothness, and contour. Their goal is to come up with a mathematical model that will allow a computer to take over for humans in making the pass/fail evaluation.

For quality controllers, "There's a fine degree of judgment that's required. It can become very tedious and nerve-wracking," explains Breece. "Right now we're spending as much on our quality control payroll as we do in the actual manufacturing of the product."

In developing a computerized knowledge base, Breece's team is finding it particularly difficult to define how a good lens scatters light or shapes images. They have succeeded, however, in getting the system to evaluate surface scratches. "It's as good as the best human operator we have, and it doesn't fatigue," says Breece. "It can find defects the operator wouldn't be able to catch, and we've been able to integrate it into the system without 'over-rejecting'" too many of the lenses. Breece hopes to have the entire expert system up and running by June.

With industries using new materials, however, making full use of such systems will take far longer. One reason is that data on these materials is so limited. If researchers themselves don't know how a composite's consistency will be affected by temperature change, they can't program the system with the necessary information. Compiling all of that data depends upon actual manufacturing runs, as well as results from theoretical or experimental research.

Conducting this research can be prohibitively expensive for manufacturers, says Reinhold Ludwig, assistant professor of electrical engineering at WPI. So, in the case of the nuclear power industry, Ludwig has done the research for them. He has developed mathematical models to help power plant operators find defects in the metal components of their reactors. The models simulate a broad array of NDE conditions that would be very expensive—or impossible—to replicate on the plant floor.

Ludwig started out by using electromagnetic fields, or eddy currents, to examine heating tubes. But electromagnetic energy can't penetrate very far beneath a hard surface. To look more deeply into thick metal parts, Ludwig turned to ultrasound, first used in the 1940s to detect submarines. "One of the main difficulties in the nuclear inspection process," explains Ludwig, "is interpreting the ultrasonic signal in order to infer how potentially dangerous the defects in reactor components really are."

To make that evaluation easier, he used a supercomputer to make finite element models of the ultrasound waves passing through flawed material. He was able to diagram hundreds of hypothetical flaws by programming the computer with a wide range of data, such as the metal's properties.

When making their diagnoses, nuclear plant technicians can compare their actual test readings with the computer-generated diagrams to determine what type of flaw they've found.

Though the supercomputer has made the evaluation process easier, technicians are still needed to monitor the signals generated by the NDE sensors. According to Tom Yolken, humans will probably continue to fill that role well into the next decade. Artificial intelligence won't become the norm until "round two," he says.

"The initial systems we see will mostly be based on expert systems that require human intervention of some kind," Yolken says. Most American industries will be using this "first generation" of NDE technology by the mid-1990s, he predicts.

"Industries are showing a lot of interest in NDE technology right now and are moving to put it into place in the new plants they're building," says Yolken. "It's crucial that they do—if we don't go this route, we'll be out-manufactured." □

The Long Wait for a New Life

PHOTOGRAPH OF LYN NELSON BY BILL DENISON

BY LAVINIA EDMUNDS

Some 15,000 people could be saved by transplants. But there aren't enough organs. Who decides who lives and who dies?

Lyn Nelson holds her X-ray up to a dining room light to show a visitor the badges of her heart wars. It resembles the X-ray pictures taken of a briefcase at an airport security gate. Her pacemaker, the size of an address book, is on the right. "It can be computer-programmed to three different rhythms," explains Nelson. "I've had that since 1986." The wire stitches holding her heart together after a 1970 operation seem like large paper clips; a steel Herrington rod runs like a ruler along her back to correct a congenital curvature of the spine. And then in a swirl of muddy grays, her defeated heart.

In her lifetime of sickness, including two strokes at age 19, most of her ailments can be traced to cardiomyopathy,

a thickening and atrophying of heart muscle. In January 1988 she entered the hospital with a swollen liver; blood had backed up into it after the right side of her heart, tough and enlarged, had slowed down to a fraction of its pumping power. Her doctor told her then that her last chance was to get a new heart. On March 21, 1988, Lyn Nelson's name, weight, and blood type were entered into the national computer network, joining those of over 900 others in search of hearts to live.

That day, Nelson, a divorced mother of two daughters, was suddenly afraid. "I'm scared. I'm alive. I'm dying," Nelson wrote in her journal.

Her body had always pulled her through brushes with death. Now she would have to rely on someone else's. It was a game in which her blood type and body frame would be matched to that of some unfortunate accident victim. A phone call, and within two hours she could be in the operating room. Nelson has waited almost a year now, and she sometimes despairs.

She wears a light blue-and-white knit shirt, sweat pants, and tennis shoes, as if to set her mind for an active life after transplant. Because exercise would enlarge her heart muscle, doctors have restricted her activities, to the point where now she rests at home most of the day. At her ranch-style house in suburban Baltimore, the rooms have a feeling of not being used—violets by the windowsill, a spotless lace tablecloth in the dining room, empty cabinets—"life on hold," she says. She conserves her energy, lying on the couch during the day, so she can be a mother when 11-year-old Gretchen returns from school.

A star on her soccer team, Gretchen bounds into the room to ask her mother's opinion on her outfit for a birthday party. "When my mom gets her organ, I'm going to run her to death," she says, before scurrying out to fix her hair. Nelson confides, "She's good at denial, like I am. I can't dwell on what would happen if the heart doesn't come."

Kim, her 21-year-old daughter, has found it more difficult. "She dreamed she had to buy a black dress to wear to my funeral," explains Nelson. "She was very upset. I try to reassure my family. That way I reassure myself. I feel like I have a purpose or I would have died long ago. The first half of my life has been to survive. The second half will be to live."

She thinks of her new life, of finally achieving health. Because of intermittent hospitalization, she was never able to finish a paralegal program she started in 1986. But she was encouraged that, even without a college background, she scored at the top of her class. Sometimes, on good days, she dreams of going all the way to law school. Her divorce has been painful, but it has given her independence and the drive to test her intelligence. She has foresworn the romance novels and cookbooks she once read, opting instead for self-education, beginning with an encyclopedia. But then on bad days, when she feels her body giving out, the 39-year-old remembers her mother, dead of heart disease at age 39.

Nelson has a strong Mormon faith. Recently, she stood up in front of her church and told the congregation how badly she wanted her life to go on: " 'I want to go to school. I want to see my children grow up. I want to get married again,' " she recalls saying. "I said, 'I want, I want,' then I looked out and saw a little 4-year-old girl, paralyzed, on a walker, and I thought, 'My goodness, how can I bellyache?' "

For now she has unpacked the bags that she had ready in the first months of waiting. But she keeps close to home, not even visiting her sister in Washington, so that if her beeper goes off, she can get one of her friends to drive her the 25 minutes to the hospital.

The waiting, Nelson says, is far worse than any of her past illnesses. Eight people on the Maryland waiting list in 1988 died because the hearts they needed were never donated.

It appears to be a simple problem—too much demand and not enough supply. Transplant operations, with a less than 10 percent survival rate 10 years ago, are no longer regarded as experimental. Recently Medicaid and other major health insurance companies have even agreed to pay for them as a last resort treatment.

Since the discovery of the anti-rejection drug Cyclosporine, survival rates have spiraled up: 85 percent of heart transplant patients now survive more than a year; 65 percent of liver transplant patients also make it beyond 12 months; and more than 90 percent of kidney transplant patients survive. The longest surviving heart transplant patient has lived 25 years since his operation; many are living healthier lives than before their surgery.

"People are dying waiting for hearts, and it seems to be getting worse, as the benefits [of the surgery] become clear. The demand has increased and supply, if anything, has diminished," says Melville Williams, the physician in charge of the

Recharged: *Carolyn Kramer's boundless energy after her transplant is a source of hope to Lyn Nelson (page IX).*

Lavinia Edmunds writes frequently on medical, family, and social issues.

Many transplant patients are leading healthier lives than they ever did before.

BILL DENISON

Hopkins transplant program. He has been helping to bolster the organ supply. According to Bruce Reitz, heart transplant surgeon and a pioneer in performing the first heart-lung transplants in the United States, at Stanford University, "We are victims of our own success."

At this writing, in the United States, there are 998 people waiting for hearts (almost triple the 350 waiting in 1987, 10 times the number in 1985). There are 557 waiting for livers, 13,728 waiting for kidneys, 162 for pancreases, and 200 for heart and lung combinations. In Maryland, the number of organ donors has shrunk, from 60 brain-dead donors in the territory of the Maryland Organ Procurement Center (MOPC) last year, to only 47 organ donors this year.

The average wait for an organ was two to four weeks; now it's two to eight months, with some going as long as two years on the edge of life. From October 1987 to October 1988, according to statistics from the United Network for Organ Sharing (UNOS)—the national computer network—13.1 percent of the patients nationwide died while waiting for hearts.

Nelson's older sister takes her to a monthly support group for prospective and past heart transplant patients at Johns Hopkins Hospital. "There's camaraderie there, knowing that you are at death's door," explains Nelson. "There are people there who've been through it. And others who are waiting like me." It was difficult for Nelson to think too hard about one of the men, who, after a wait of 18 months, was bedridden and represented at the meeting by his wife. He had Nelson's blood type and had been waiting longer, which put him higher on the priority list. (A month later, he got a new heart.)

Nelson enjoys just looking at two others who got their hearts: Carolyn Kramer, a slim, radiant mother of three who had her transplant in 1985, and Kim Claudfelter, a 22-year-old who is playing sports for the first time in her life, one year after her operation. Kramer, who developed cardiomyopathy during her third pregnancy, went through a tough year of rejection after her transplant. But now she's offering her support to everyone, "knowing what it involves."

Others who have had transplant surgery tell of extreme swings of mood and of the trials of life after transplant. On this night, Nelson does not recognize an 18-year-old, whose face and body are

Allocating organs to the sickest people illustrates a thorny issue: There are some whom surgery cannot save.

Heartfelt dilemmas: *People tend to be too conservative in deciding whether to donate organs, says CWRU ethicist Mary Mahowald (left). But Tom Shannon, a bioethics specialist at WPI, wonders how far technology should go.*

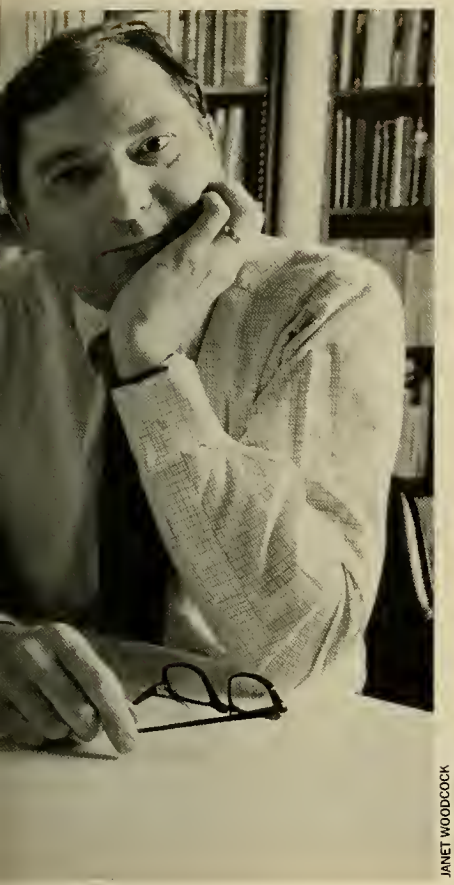
swollen by the drug Prednisone, given to combat her body's rejection of the organ. Upset by the physical changes, the drug's mood-altering effects, and the news that she's "in rejection," the young woman can hardly speak without tears. But for all their differences, members of the support group offer each other hope and a touch of gallows humor, releasing some of the tension.

For those waiting, the mood grows increasingly morbid. "What do you do? You pray that a building collapses or you go to a car race and pick out some healthy young men," says Nelson. Nervous laughter. Adds one woman whose husband has been waiting for months, "I never want to see anyone die, but if they do, I hope they're O-positive and 160 pounds."

Certainly the system for delegating organs has improved from the days of emotionally wrenching TV appeals, to the relief of those who would prefer not to parade their illnesses and agonies before millions. In the early years of the Reagan administration, aggressive parents with adorable, critically ill children had a decided advantage in the organ stakes. But the circus of media attention on whatever case was spotlighted contrasted with the quiet desperation of those who did not want celebrity. Those in this support group shun the public spotlight. "I don't think a person waiting should have to go through that. Number one, they're dying. Number two, someone will have to die," says Kramer.

In the old system, the rich and privileged found shortcuts. For example, a pediatrician at a meeting in Washington made an appeal to his colleagues: "Please find a liver for my child who's going to die." And the next month, his daughter had her life-saving organ. A series of articles in the *Pittsburgh Press* in 1985 detailed the inequities of a system that allowed foreign kidneys to go to members of the Saudi royal family and to others who paid the highest price, instead of to Americans on the waiting list.

To establish a fairer system and to encourage sharing between regions, the National Organ Transplantation Act, which passed in 1984, called for setting up a computer network and rules for distribution developed with the input of ethicists, transplant surgeons, and the public. Each region of the country has a UNOS administrator who oversees the gathering and distribution of organs for



JANET WOODCOCK

that area. In the past, when an organ was not used by one area, a regional procurement officer would call another part of that region to check on other possible recipients. But it was an informal network, based on word-of-telephone.

UNOS, based in Richmond, Virginia, began in October 1987 to list the people who need used body parts—hearts, lungs, kidneys, corneas, tissues—with categories to indicate priority. "The idea is to have one set of rules for everyone," said John Gold, deputy director of the Department of Health and Human Services (HHS), Division of Organ Transplantation. "It's about as equitable and fair as it's going to be at this point," adds Reitz, a member of the group that developed the criteria.

But sharing organs, particularly hearts, is minimal between regions. As Reitz points out, an increasing number of transplant centers constantly need organs. The established policy has been for organs to go to the nearest center. The system is evolving, says Linda Sheaffer, director of the HHS Division of Organ Transplantation. "We know it's not perfect yet. UNOS has had to rethink its policies, particularly in the allocation of organs. But there was a lot of abuse in the other system. Now you play by the rules or you can get your Medicare funds withheld."

Beginning this year, the method for delegating hearts changed from six categories given for a range of physical conditions, to two—Status I (in intensive care) and Status II (at home). One procurement worker refers to the categories as "the dying" and "non-dying." In the past, reflecting the reality of the shortage, organ procurement workers developed their own term: They call it simply *stat*. It means, says Dave Kappus, director of MOPC, "hours to live."

As more people qualify for transplants, more fall into the same Stat I category on the UNOS computer, so that, all criteria being equal, the physician must determine which patient is most urgent. Physicians have always had that final authority to assess the medical condition of their patients. But the system creates some difficult dilemmas. Given the worsening condition of a patient on the waiting list, some physicians will opt to keep a heart or other scarce organ for a Stat II patient rather than sharing it with another nearby city with a more medically urgent case. "If you only use it for the gravely ill, you'll have dismal results," says Melville Williams, the Hopkins liver transplant surgeon.

"When it comes down to individual cases, it's a very, very difficult decision," says Alexander Geha, director of cardiothoracic surgery at University Hospital, one of the teaching hospitals of Case Western Reserve University (CWRU). "Suppose you have a family member on life-sustaining devices. Her condition has deteriorated so that her chances of making it are 50-50. Then you have a brother waiting at home who needs it to live, and his chances of survival are 90 percent. What would you like us to do?"

According to UNOS rules, the physicians must balance survivability with medical urgency. Geha says he bypassed a patient when a heart became available because he did not think she would survive the tough recovery period. "I get very frustrated when such a dilemma happens, but it happens."

Patients are faced with cross-purposes—wanting to reach a critical point in order to qualify for an organ, but willing themselves not to deteriorate to death. In August, Nelson entered the intensive care unit (ICU) for treatment for atrial fibrillation. Her heart, which was not filling with enough blood, sped up, beating so rapidly she could feel its walls shaking. In the ICU, she was given an electric shock to jog the heart back into its rhythm, and her pacemaker was reset. Four times Nelson has fought off atrial fib, as she calls it, but next time could be fatal, her doctor says. If a heart had become available while she was in the ICU, she was told, she would have been at the top of the list to receive it. One doctor actually advised her not to go home, because then she would drop down a notch in priority. "You play against yourself. You get sicker, you're one up," says Nelson. But then she stabilized.

With her place on the UNOS computer, Nelson has advanced at least one stage ahead in the game. To be listed, a patient must have the right insurance or be able to finance the operation, estimated at $90,000, not counting about $10,000 per year for anti-rejection medicine. Those who are obese or alcoholics are deemed poor risks. Still, the criteria for the operation have expanded. For example, in 1983, the operations were limited to people under 50. Today they may be performed on 65-year-olds. (Insurance policies do not fund the operations for people over 53.)

But with longer waits and sicker patients, survival rates are beginning to go down for the first time. Dave Mainous, executive director of LifeBanc, a procurement agency that serves northeastern Ohio, has seen 20 on that waiting list die this year. "We have very few home on the waiting list. Patients selected for heart transplantation in our area are sicker and tend to get more so." Statistics in the July/August *Journal of Heart Transplantation* show that death rates 30 days after transplantation this year have gone up to 11 percent, from about 7 percent in 1986.

The allocation of organs to the sickest people illustrates a thorny issue that society must deal with, says Thomas Shannon, professor of ethics at Worcester Polytechnic Institute. He admits that there are some who cannot be saved, despite the most advanced technology. "We have reached the point where we need to say, 'We're sorry, there's nothing we can do now,'" says Shannon, who wrote *An Introduction to Bioethics*. "We need to identify issues to frame a debate that examines the best expenditure of resources"—whether for funding heart transplants or funding programs to prevent heart disease.

But few in the field would take away the surgeon's authority to prescribe the appropriate treatment after determining a patient's condition. Consider the case of Kim Claudfelter, the 19-year-old student from suburban Wilmington, Delaware. Claudfelter would have died if doctors had been forced to go through the UNOS system. When surgeons opened her up, they found inoperable deterioration. They had no choice but to keep her on a bypass machine until they could locate a heart. It was a tremendous risk, given the short supply. But in a tragic turn of fortune, a motorcycle accident victim had that day been declared brain-dead in a shock trauma unit across town. The donor had Claudfelter's blood type and the right weight.

"She's probably the luckiest girl in the world," says Molly Dice, the procurement officer who helped in the complex set of steps that led to saving Claudfelter's life. The transaction was made through a phone call between MOPC and surgeons at Hopkins Hospital. Claudfelter never made it to the computer list. The next day she would wake up with another person's healthy heart pumping blood to her cheeks. "She wasn't a stat of any kind," says MOPC director Dave Kappus. "She was a miracle."

At the support meeting, Claudfelter marvels over her energy. "When I got out of the hospital, I pushed myself to do more. When you have health, and you never had it before, you have to restrain yourself from trying to do everything. I never thought I could be so normal."

As they face a growing demand for transplants, what frustrates surgeons as well as patients is that the viable organs resulting from brain deaths are not being used. Only 2 percent of all deaths qualify as brain deaths—after which a respirator can keep vital organs supplied with the oxygen and blood necessary to prevent deterioration. But that amounts to 20,000 potential donors nationwide, more than enough to supply the 15,000 Americans waiting for organs. Only 15 percent of the public now has signed up to become organ donors, but a Gallup Poll shows 70 percent would agree to donate if asked.

Declining to become an organ donor becomes an ethical issue to some, particularly to those who are waiting for a second chance at life. Congress passed a law that would enable the federal government to withhold Medicaid and Medicare reimbursements for those hospitals that do not request organs from potential donors. Forty-three states and the District of Columbia have now passed laws requiring hospitals to give all families of victims of traumatic accidents the opportunity to donate their loved one's organs.

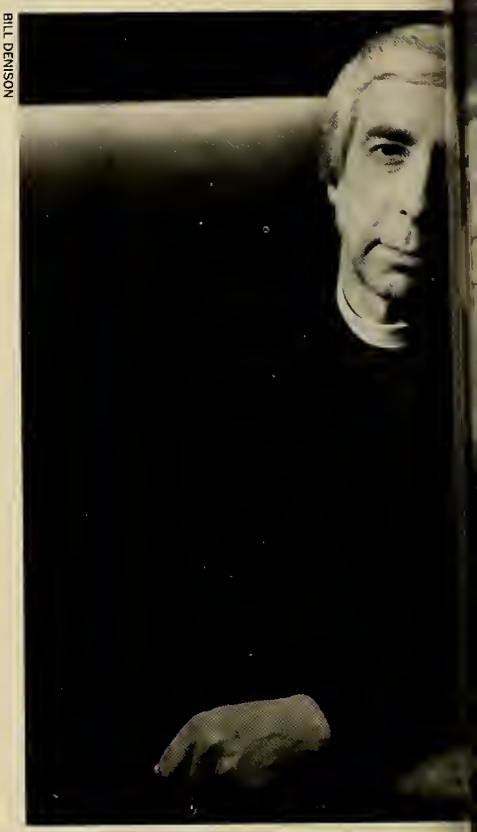
So far, the results are mixed, leading some to proclaim the effort a failure, while others want to give it time. In Maryland, a required request law, passed in 1987, not only requires families of candidates for organ donation to be asked for organs, but requires that everyone admitted to the hospital be asked whether they are organ donors. But it has failed to increase the supply. Before the law, 60 patients gave kidneys, hearts, livers, and heart-lung sets. Last year as of November 30, only 47 became donors.

In Ohio, since enactment of the required request law, more people are being asked, but the denial rate has gone up to 43 percent, higher than the 20 to 30 percent refusal most surveys of the general population have shown, according to Mainous at LifeBanc.

"In 100 percent of the cases when physicians and nurses who are uncomfortable ask, they are turned down," Mainous explains. "I've heard how awkward it can be. A doctor goes in and says, 'Your husband is dead and the state is requiring me to ask if you would be willing to donate his organs.' That's not what I call a sensitively placed request. We need to look at who is doing the asking and find people who are comfortable, or are trained in that difficult situation." Most procurement offices have staff counselors who can be dispatched to the hospital. Trained in the psychology of grieving and knowledgeable enough to answer questions about the process, they are best able to approach families, Mainous believes.

The problem in Maryland, according to Kappus, is that physicians simply are not asking. Kappus, who got his business degree from the Hopkins School of Continuing Studies, also provides special counselors who can be sent out to talk with families upon request, but they are not called that often. Physicians prefer not to have a third party present during the difficult period of informing a family of the death of a loved one, Kappus says.

Underlying the reluctance to donate organs are some deep cultural and religious ideas about death and the body,



BILL DENISON

Precious gift: *Aware of the shortage of organs, the Rev. Roger Butts, WMC '59, (above) decided to become a donor. Such noble acts could become a duty as the need grows, says the Rev. Jim McCartney of Villanova (right).*

wrote William F. May in an article on "Religious Justifications for Donating Body Parts" in a report from the New York-based Hastings Center. No religion explicitly prohibits organ donation, but a survey of 96 religious institutions indicates lukewarm concern. "While Christian ethics provide positive warrants for the act of giving, the future of human existence is in some sense embodied in the belief in resurrection," says May. And somehow not to have one's whole body intact seems to threaten some people and their hopes for an afterlife. A nondonor expresses it this way: "Donating your organs is a noble thing to do, but on some level, I'm afraid that I might still need my body. I guess I have an instinct to preserve myself."

The Rev. Roger Butts, a chaplain at Church Home and Hospital in Baltimore and a 1959 graduate of Western Maryland College, regards organ donation as a moral duty. He is keenly aware of how few people sign up to be donors, since

"Knowing part of me will live in someone else eases that desperate knowledge of my own mortality."

ADAM GORDON

he reviews medical admission records, where patients indicate whether they would be donors. More than 60 percent of this group says no, he estimates.

More people would become donors if the question were timed better and they understood the need and the process of organ donation, Rev. Butts believes. It was in contemplating his own death, facing a triple bypass operation, that he decided to become an organ donor. "My illness really brought it to the fore. This old carcass of mine was not what I thought it was. If this were the time to check out, I would leave something for someone else. You do have to come to grips with your own mortality. Knowing part of me will live in someone else eases that desperate knowledge of my own imminent mortality."

Under the federal Uniform Anatomical Gift Act, a person can indicate willingness to donate organs after death by signing a statement. Massachusetts has tried to make it as easy as signing a blank on your driver's license. An estimated 20 to 25 percent of the general public has signed donor cards. Yet donor cards are not sufficient. Physicians will not remove organs without permission of the immediate family, who are asked after the declaration of brain death. Because most organ donors are the victims of traumatic accidents, their personal possessions, including the wallet containing the donor card, are often lost at the scene of the accident, according to Howard Nathan, executive director of the Delaware Valley Transplant Program. Of 2,000 organ donors over the last 15 years that have come through that program (which covers transplant hospitals in the Philadelphia area), Nathan estimates only 100 have signed donor cards.

However, driver's licenses and donor cards serve as "good tools for public awareness," says Nathan. In one case, parents refused permission to take the organs of their 21-year-old son who had died in an automobile accident. In searching his wallet upon return home, the mother discovered a donor card and called the hospital back to grant permission.

Most ethicists agree that organs, from a purely practical point of view, must be donated anonymously to prevent any black market in organs. "It's important to keep money out of it," says the Rev. Donald Burt, O.S.A., professor of philosophy at Villanova. "Our society has a natural tendency to greed. The regulations that provide for giving organs prevent people from making money selling organs and tissues. Without that stipulation, it could come down to a case of manipulation of the defenseless and poor and subordination of the disadvantaged."

Preserving anonymity is important, too, for the relationship between those who give and those who receive. In a study of kidney donors who were relatives of the donees, social scientist Roberta Simmons found when recipients did not express what the donors considered a reasonable amount of gratitude, the donor felt angry and used. In another case, when the identity of the donor was discovered as a victim of a gunshot

wound in a drug battle, a family grew upset. While support group member Richard Duke knows his heart donor was a 35-year-old man, he prefers not to know the details. "It would bother me," says Duke. "I'm grateful, but it would bring it too close."

After the transplant, feelings for the donor—that individual who had to die for the recipient to live—present a major psychological problem in recovery. Is there some way to reach out to the family? Lyn Nelson asks the four in the group who've had transplants: "I guess knowing the identity of the family wouldn't be healthy. Like knowing the family of your adopted child. But do you all write a letter back?"

Laurel, four months out of her operation, is silent, shakes her head, then cries. "It's hard to deal with the fact that you're living because someone else died," she says.

Despite the uneasy feelings that follow this most intimate exchange of life, giving an organ presents a special opportunity for genuine altruism in our society, says the Rev. Jim McCartney, who teaches philosophy part time at Villanova and serves as ethics consultant for Allegheny Medical Center in St. Petersburg, Florida. "Now, it's a matter of what we in the Catholic Church call supererogation, a noble act," says Father McCartney. "But as the need becomes greater, it could move into a duty."

Most controversial in the debate over how to increase organ donation is the concept of presumed consent. This idea assumes most people would give their organs if asked—a proposition supported by Gallup polls. Mary Mahowald, co-director of the Center for Biomedical Ethics at CWRU School of Medicine, can see the logic of presumed consent as the next step. "I believe people tend to be more generous about disposition of their own organs," but more reluctant when it comes to dealing with those of a family member. Yet, she believes, the best interpretation would be that of giving someone else life. "Most people are too conservative in trying to interpret the wishes of their loved ones."

However, WPI ethicist Thomas Shannon finds the idea of presumed consent abhorrent, for it takes away one's last bodily right in death. "Presumed consent assumes my body belongs to the state. It's dangerous, because it could override an individual's will," says Shannon. He believes required consent can work if given time for education about the need for organ donation. "Basically, presumed consent says your value is a function of the state. After you die, your body is a symbol of who you are. Our society doesn't let us hack up bodies at will. The body is the physical place where there used to be a person."

Villanova's Burt thinks a mandatory program, in the worst case, could lead to bioemporiums, where bodies are kept on life support until their organs can be harvested, at the pleasure of the state.

As organ transplants become more commonplace, some believe presumed consent might become a more palatable solution. Such a procedure is standard when medical examiners retrieve corneas from autopsies. Worries over presumed consent may be unfounded, anyway. In Sweden, where presumed consent is the rule and those who don't want to be donors carry nondonor cards, consent from the family is still obtained before organs are retrieved.

Kappus is willing to give major education programs at least two more years before he would use the pressure of the federal law that withholds Medicare or Medicaid funds from institutions that can't prove they are making requests of every accident victim's family. "We're getting out to hospitals to make sure they have procedures set up now," says Kappus. "And we're educating them as to what the procedures are and how to implement them. The law says every time a death occurs, you must record in the medical records the disposition of whether the family agreed to donate the organs. But this isn't being done."

Procurement agencies are providing seminars to help designated requesters be more sensitive to the grieving process. In a one-day seminar, counselors from MOPC teach body language and the psychology of grieving, and address common misconceptions. Francis Scott Key Hospital in Baltimore has a model program featuring an advocate who makes daily rounds to help identify potential donors and to remind nurses and doctors to ask. So far referrals are up 400 percent, says organ donor advocate Debbi Knott. But the glowing figure reflects the dismal past: Organ donations are up from none at all in 1986 to two in 1988. At the Boston-based New England Organ Bank, covering six states, acting secretary-director Robert Kirkman plans to educate nurses and physicians about making requests and to increase his staff of eight coordinators. "We don't have statistics, although our impression is organs follow where they've been," says Kirkman.

Over the long run, to fill the shortage of human hearts, transplant surgeons predict the development of better artificial hearts. Immunological problems of using animal organs will take longer to be worked out, says Hopkins surgeon William Baumgartner.

Now Lyn Nelson lives with a roommate who buys groceries, cleans, and cooks. With her ear attuned to her beeper, she hopes to grow worse without dying. She gains hope from the support group, particularly from the success stories of Kim Claudfelter and Carolyn Kramer. "My therapy is calling Carolyn. It's cheaper than a psychiatrist.

"I need to talk. Help me. I need words of encouragement," Nelson says. "Tell me how wonderful your life is now, so I will have something to hold on to."

"I know what you're going through," Kramer replies. "It's hard, even after the transplant. But now my life is so normal it's frightening. I just got back from taking Carl to karate. Jenny has to be picked up from school. We're having people over to dinner and I haven't made it yet. And I even have energy left over to scream at my kids! The main thing is keeping that positive outlook."

"How about sex?" Nelson asks. "I want to marry again."

"There's a test you take at the hospital to clear you: If you can climb up two flights of stairs, they allow you to have sex," Kramer replies.

Nelson laughs, a little nervously. "I'm always getting ahead of my chickens before the eggs."

Back home, resting against a stack of pillows to help her breathe, Lyn Nelson says she has learned to enjoy the little things in life. Despite the surrounding subdivision, the view from the glass doors in her dining room is pastoral and soothing—fields from a dairy farm. "I really enjoyed fall, the change of the leaves. You know that story of Freddy the Leaf. Freddy wouldn't give up, he kept hanging on. I think that's me."

The operation frightens her. But Nelson has already toughed it out—in and out of hospitals. Deciding whether to undergo a heart transplant wasn't hard. "You have no choice. Either do or die." It's the waiting that could kill her. □

Confronting a Crisis in Our Schools

More than 30 years ago, WPI first reached out a helping hand to the public schools. Today a new center aims for a brighter future for education and WPI.

JANET WOODCOCK

Cindy M. Bachelder '90 talks over a project with John van Alstyne, professor of mathematics and director of the WPI School-College Collaborative in Math and Science Education. The center asks area schools, "How can we help your teachers and students by using ours," van Alstyne says.

By Michael V. Shanley

Lest anyone underestimate the crisis, William R. Grogan, dean of undergraduate studies, sounds the alarm:

"Both from a national perspective and for our own salvation, we've got to get in there and work with the people who want to save it and strengthen it and support it."

The "it" is pre-college education. "There" is the nation's elementary and secondary schools.

"We can't just sit back," Grogan says, speaking for colleges of science and engineering nationwide, "because there are plenty of people who aren't going to help."

With that in mind, WPI last spring made clear its own commitment by establishing the WPI School-College Collaboration in Math and Science Education. The center brings together a number of disparate programs, some of which have been in place for years. All share a common bond: they aim to help students and teachers in elementary and secondary education.

The scope is impressive: in-service institutes and visiting scholar programs for teachers; summer programs for students; an outreach effort that targets minorities; computer classes for bright elementary and junior high schoolers; a statewide mathematics competition and a regional science fair; presentations on topics such as solar electrification; and software evaluation for educational computer programs.

And especially, dozens of student projects—to help disadvantaged and handicapped students, to evaluate teaching methods, to bring technology into the classroom.

Where once these programs operated in isolation, they now have a collective identity and a central focus.

"We had reached a critical mass of activity," says Grogan in explaining the center's beginnings. "And we wanted to make sure that the programs enjoyed the recognition and support base they deserved. What's most important is that research and ideas be shared."

If the center's collective scope is far-reaching, and the subject matter at times complex, the intent remains disarmingly simple.

Says center director John van Alstyne, professor of mathematics and former dean of undergraduate advising, "We're going

out into the schools and asking, 'How can we help your students and teachers by using ours?' "

"There's been a lot in the popular literature," he continues, "about the poor quality of secondary school education. And there's been a lot about colleges facing declining enrollments. This is a way to deal with both issues. For too long a time, engineering colleges didn't pay much attention to what was going on in the public schools—and vice versa. That created a great gap between each group's idealism and the reality that had to be dealt with," he says.

Worse than that, it set into motion a profoundly important chain of events that, unchecked, had the potential to bring colleges of science and engineering to their knees.

Says Grogan, "At first, there was the perception that there wasn't really a problem at all. There were some changes, sure, but the students were coming and they seemed pretty good.

"In reality, the changes were major. We were still the same, but the world was changing around us—and rapidly."

As an example, Grogan points to a crucial demographic shift that for years went virtually ignored. "There are very few minorities going into engineering nationwide, yet in many states minorities are on their way to becoming majorities."

And that's only one of what Grogan calls today's "enormously depressing statistics." The others document in cold, dispiriting numbers, growing apathy and anxiety about science and mathematics among the nation's teachers, coupled with a plunging level of interest in anything mathematical among students.

As these upheavals were taking place in the elementary and secondary schools, Grogan says, "engineering colleges tended to point their fingers and say tsk-tsk."

Whatever the lost opportunities of the past, the demands of the present are clear.

"We've got to get in there and work with the people in these systems," says Grogan. "And by that, I don't mean telling them what to do. That won't work. We've got to bring our expertise and talent to their service and work with them cooperatively on problems of mutual concern."

As the stories on the following pages attest, that effort is well under way.

Shanley is a frequent contributor to the Journal.

▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲

Helping Teachers Bring Science and Math Alive

ROBERT S. ARNOLD

Ronald D. Cheetham, director of the Master of Natural Science Program.

In the beginning, there was the Master of Natural Science (MNS) program. And it was good.

In addition to being the first of WPI's school-college programs, it was among the first of such efforts nationwide.

The year was 1957, the beginning of President Eisenhower's second term. Nationally, things were going well, except the Russians were making people nervous with this Sputnik thing.

"After those satellites went up, our government was spurred into action," recalls Richard F. Morton, professor emeritus of physics and founder of the MNS program. "They began to make money available to improve the teaching of science in the secondary schools."

WPI got its first grant from the National Science Foundation in 1957 for a summer institute for high school physics teachers. That was followed by a proposal for an in-service institute to be held in the evenings during the regular school year.

With the second grant, a two-year master's program was launched in the fall of 1958. Under the plan, the students (who were teachers) completed eight semester hours in the fall and spring, and another

eight during the summer.

"A number of colleges at that time had summer institutes," says Morton, "but we were the first to combine the summer with the in-service. The NSF would later call these 'sequential institutes.' "

Then, as now, science teachers came to WPI from all over New England. Both Morton and current director Ronald D. Cheetham, associate professor of biology and biotechnology, marvel at the number of people who have driven in over the years from the far reaches of New Hampshire, Vermont and Maine.

"Sometimes they'd make it here during snowstorms before the people coming in from Shrewsbury," chuckles Morton.

The program has been continually refined, adding courses in biology, chemistry and mathematics, as well as physics. Although the summer component was eventually eliminated, making it a four-year program, 32 semester hours remain the requirement for graduation.

"Our philosophy is to provide breadth rather than depth," explains Cheetham. "Also, we try to focus on topics that will be of use in everyday teaching. So we don't take examples from high energy physics at a cyclotron. We prefer to talk about friction or something they can bring back to a high school classroom and relate to their own students."

In 1976, a similar master's degree program, the Master of Mathematics (MM) program, aimed at secondary school mathematics teachers, was set in place.

Both programs now offer alternate two-year course sequences. Participants take two courses per semester. They drive in one day a week—on Tuesdays—for back-to-back courses.

As MM director Peter R. Christopher notes, "That's a lot of Tuesdays. And what happens is we all get to know one another very well. Over the course of the four years, people's lives change; they go through crises. There's a real bond that develops. It's a family situation by the time they finish."

The courses are taught by full-time WPI faculty. In the case of the MNS program, faculty members are drawn from each of the four disciplines.

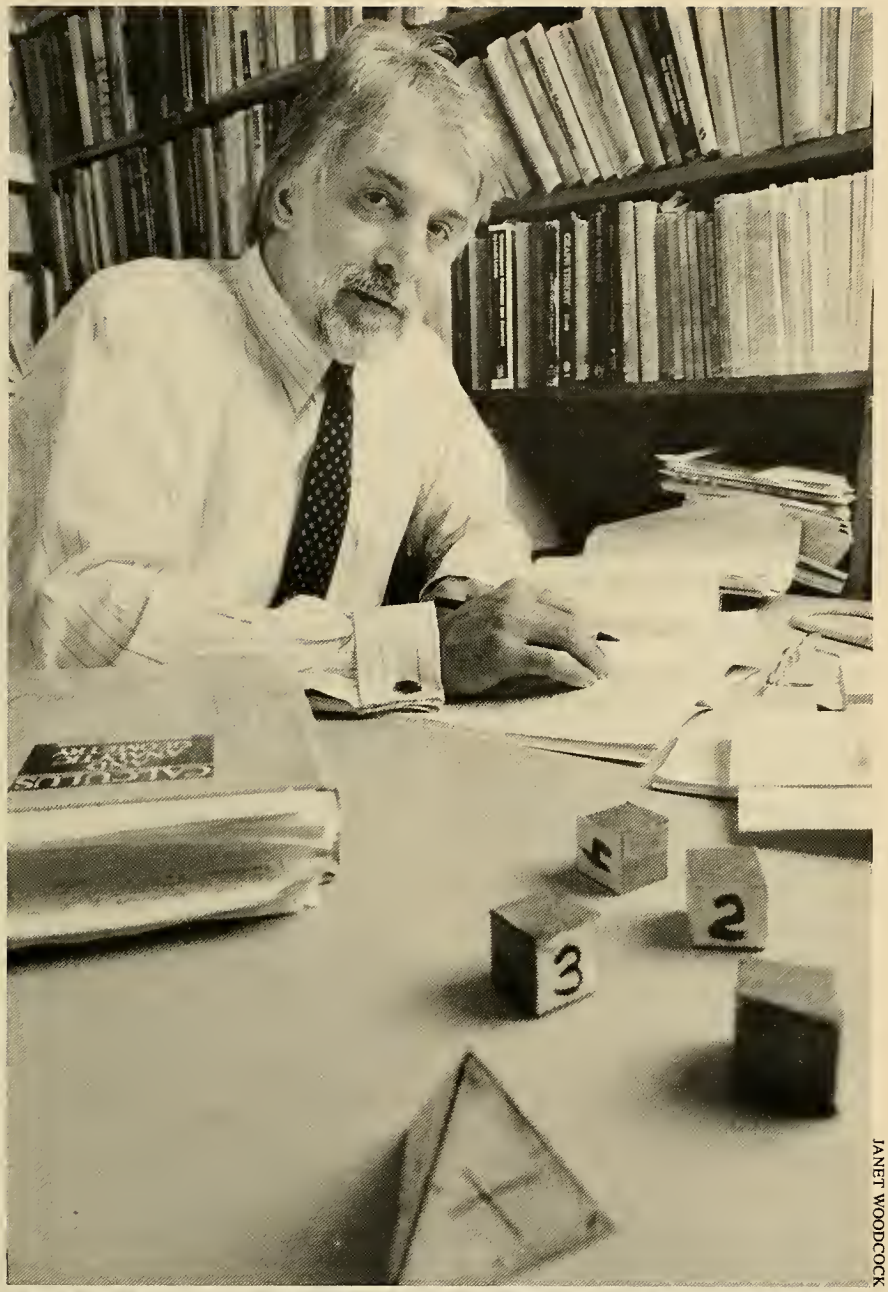
Morton, Cheetham and Christopher are quick to point to the quality and commitment of the hundreds of teachers who have graduated over the years.

Morton ticks off the names of several MNS graduates who have done exceptionally well since graduation. People like Robert F. Kelley '60, who, Morton says, started at Worcester's Chandler Jr. High and went on to North High, then to Worcester State College, where he is professor emeritus of natural science and physics. William H. Fitzgibbon '60 went on to become a dean at Fitchburg State College. Thomas J. Ford's ('68) ideas on education were discussed in *Reader's Digest*.

According to John van Alstyne, two program graduates earned teacher-of-the-year honors, one in Rhode Island and one in New Hampshire.

"You hear a lot of horror stories these days," says Christopher, "about what's going on in education, about teachers who don't care. Well, that's not these people—they're very dedicated."

They're also very different from the run-of-the-mill graduate student. "Because they're all teachers themselves," explains Cheetham, "they have strong opinions about how they should be taught. They're



JANET WOODCOCK

Peter R. Christopher, associate professor of mathematics and head of WPI's Master of Mathematics program. "Many of our teachers have had it with education courses," Christopher says. "We concentrate exclusively on mathematics—that's what they really want to feel comfortable with."

professionals in their own right."

Adds Christopher, "They're perfectionists. When undergraduates hand in papers, you're lucky if you can read their names. But these teachers like to get everything just right. They take pride in what they do." As proof, he pulls out a stack of neatly printed and typed homework assignments.

Christopher attributes at least part of the MM program's success to its special focus. "Many of the teachers have had it up to here with education courses," he says. "We concentrate exclusively on mathematics—that's what they really want to feel comfortable with."

Some of the teachers have transferred to mathematics from other fields, Christopher says, or are just getting into teaching after having been out of college for many years. "They need to be renewed and refreshed," he says.

While both courses are rigorous, the natural science program must be delicately structured.

"They're highly variable in terms of ability," says Cheetham of the participants. "And extremely diverse in terms of background. For example, you might have a physics teacher who last took biology 25 years ago in high school, when DNA was just discovered. And in the same class you might have a person who graduated two years ago from a first-rate college and is teaching biology. So when you make up an exam, whom do you make it up for?

"Since we cover the four basic fields of science, each of the students has one-quarter of the curriculum where he's in control, and three-quarters where he's not. That makes it challenging for us."

Since 1974, when the NSF stopped supporting degree programs, WPI has been running the program internally, on a tuition basis. Since full tuition would be prohibitive for many high school teachers, 40 percent scholarships are offered.

Cheetham expresses frustration that some funding sources overlook programs such as the MM and the MNS because they're not sufficiently "cutting edge."

"Are we developing some new educational philosophy, or attempting some innovative methodology that's never been tried before? The answer is no. What we're trying to do is help high school teachers become better teachers by bringing them up-to-date and giving them a rigorous program. And that's certainly a legitimate goal," he says.

Morton, Cheetham and Christopher all point out that the programs benefit WPI,

Stepping Off the "Calculus Fast Track"

Loring Coes III sees it happen more and more frequently in the classrooms of the Rocky Hill School in Warwick, R.I. Coes, who is chairman of the school's mathematics department and president of the Rhode Island Mathematics Teachers Association, says students, for one reason or another, are developing the wrong attitude about math.

"They feel that math should be difficult," says Coes, a 1986 graduate of WPI's Master of Mathematics (MM) program. "They think that if it isn't hard and boring, it's not math."

That's a problem that Coes says he would like to solve. The solution, he notes, may not be that difficult to find. He says the trick is to make students see the connection between math and the real world in which they live.

Last year Coes was honored for his ideas on mathematics education and innovative classroom techniques with the Presidential Award for Excellence in Science and Mathematics Teaching. The award, one of 100 presented to U.S. teachers, included a $7,500 grant from the National Science Foundation.

The problems that turn students off to mathematics begin in grade school, Coes says. In the early grades, teachers themselves are often intimidated by mathematics. Compounding things is a curriculum that emphasizes the continual review of basic arithmetic concepts.

"If you look at most of the popular textbooks for young students, you see a great deal of repetition of the same skills. There is very little introduction of new material. Then, suddenly, in the eighth or ninth grade, we hit kids with algebra. We bore them to death for the first seven years and then we scare them to death. After that you see kids starting to drop out of mathematics."

Algebra is the beginning of what Coes calls the "calculus fast track," the standard high school math curriculum that seeks to teach students all of the prerequisites for calculus by the time they graduate—a trend that began after World War II. In this way, Coes says, high schools do their part to prepare the next generation of scientists and engineers.

STEVE SZYDLOWSKI, PROVIDENCE JOURNAL-BULLETIN

"We're losing kids every year," says MM graduate Loring Coes III.

"We've stripped away much of what is potentially interesting and challenging at the high school level on the fast track to calculus," Coes says. "We have had to cut out a lot of the beauty of math and left kids wondering why they are doing these things. Very rarely are we able to show them directly that this stuff is good

for solving real problems."

To fill that gap, Coes says he tries to illustrate his courses with real-world examples. In his statistics class students learn about probability by flipping a set of 12 coins over and over again to prove that, while a jury composed of nine men and three women may seem biased, the combination can be expected to show up reasonably often in the normal course of events. Students learn about correlations by comparing factors that hinder safe driving at intersections near the school with accident data.

As a student in the MM program at WPI, Coes says he became intrigued with discrete mathematics, a relatively new area of math which has proved useful in solving problems in electronics, management and other fields. While calculus focuses on values that vary continuously—such as velocity, temperature or pressure—discrete math looks at values that vary in discrete steps—such as days on a calendar, periods on a class schedule or the energy states of electrons spinning around an atom.

Since discrete math is better suited to solving the problems most of us encounter in our daily lives, Coes says it may prove to be an alternative to the calculus fast track for students who do not plan to pursue science and engineering careers.

In addition to making math relevant to his students' own lives, Coes says he works hard to find ways to make math concepts stick in students' minds. One technique involves having students write about mathematics. Coes, who earned his bachelor's degree in English at Williams College and began his career as a reading teacher in Washington, D.C., says his tests nearly always require students to describe mathematical principles in words.

"There is a nice definition of a complete sentence—that it is a complete thought," Coes says. "Having students write about math is a good way to see if they are absorbing complete mathematical thoughts."

These and other techniques can change the tide and bring students back into the mathematics fold, Coes believes. But the job will not be an easy one.

"Across the nation, we're losing kids every year," he says. "We've got a tremendous challenge ahead of us."

—Michael Dorsey

and not just the teachers they serve.

"We have graduates of the program in every corner of New England," notes Morton. "And they serve as a recruiting body for us. They've sent us a lot of students over the years."

Adds Cheetham, "By and large, people who complete the program are happy with the education they received, and they go back to their schools and reflect positively on WPI as an academic institution."

John van Alstyne, who has taught in the programs, sums it up: "We owe them a debt of gratitude. They've sent us some great students, and that's a tremendous gift."

▲ ▲ ▲ ▲ ▲ ▲

Bringing Students to the Frontiers of Knowledge

In biology, they're splicing and transferring genes to engineer new bacteria, mapping the DNA of a virus, and using electrophysiological amplifiers to eavesdrop on nerve and muscle communication.

In physics, they're working with high-temperature superconductors.

In chemistry, it's the synthesis and spectroscopy of chromium acetylacetamate.

Sounds like lab assignments for juniors, right? Yes—high school juniors.

They come to WPI from all over New England to spend two summer weeks living in the residence halls, studying with WPI professors, and having lots of fun in the bargain.

"Frontiers in Science and Mathematics," entering its eighth year, is a dream come true for bright students who hunger for a taste of college-style learning and research.

"They get a chance to do things that are completely different from what they've been exposed to in their high schools," says Frontiers director Thomas H. Keil, a professor of physics. "Our goal is to get them excited about science and mathematics by providing an exciting learning and research experience."

Participants in WPI's Frontiers in Science and Mathematics "get a chance to do things that are completely different from what they've been exposed to in their high schools," says director Thomas H. Keil, professor of physics.

ROBERT S. ARNOLD

Students, about 50 each year, spend their days working in one of six areas of concentration: physics, chemistry, mathematics, biology, civil engineering or solar photovoltaics. In the evenings and on weekends, there are guest speakers and supervised study sessions, social events and athletics.

A typical day might feature a lecture and a lab session in the chosen field of study, broken up by a lunch break and perhaps a humanities course that examines the interaction of science and technology.

Field trips also play a role. Students in the civil engineering section, for example, might travel to major construction sites, resource recovery plants or water treatment facilities.

The groups gather together every so often to explore topics of mutual interest. In the past, these combined sessions have focused on such topics as computers and artificial intelligence, ethics in science, and educational and career goals.

On-campus journeys to the robotics and computer-aided design laboratories are also a part of the itinerary.

The program has evolved over the years in response to student comments.

"They're really interesting," says Keil of the students, about a third of whom are female. "Their curiosity shows through all the time. They want to have fun with science and math in a way that's different from undergraduates. Once you're enrolled in college, you tend to be more serious, and curiosity gets squeezed out a little bit. But these high school students are not yet afraid of college."

The program's principal lecturers—one in each of the six major disciplines—are all drawn from the WPI faculty. More than a dozen other WPI faculty members make presentations during the combined sessions. In addition, eight upperclassmen serve as laboratory and study assistants, while three more act as residence hall advisors.

According to the most important arbiters—the students themselves—Frontiers is a winner. In their evaluations each year, the students have graded the program an average of nine on a scale of one to 10. More tellingly, they have unanimously answered "yes" when asked if they would recommend the program to their friends and classmates.

"It's important for WPI," says Keil of Frontiers. "It helps us with our recruiting effort, and also sends back to the high schools the message that we're not just an engineering college; that we're an attractive place for science majors."

To help make the program available to a greater number of students, the college has over the years provided scholarship money by securing grants from New England industry.

"We hope to do more of that in the future," says Keil. "Although we work hard to keep costs down, there are still too many students we just can't reach out to."

▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲

Putting Students on the Educational Front Lines

Under the best of circumstances, teaching aquatic life, habitats and the food chain to elementary school students would be daunting.

And if the students were learning disabled? Doubly daunting.

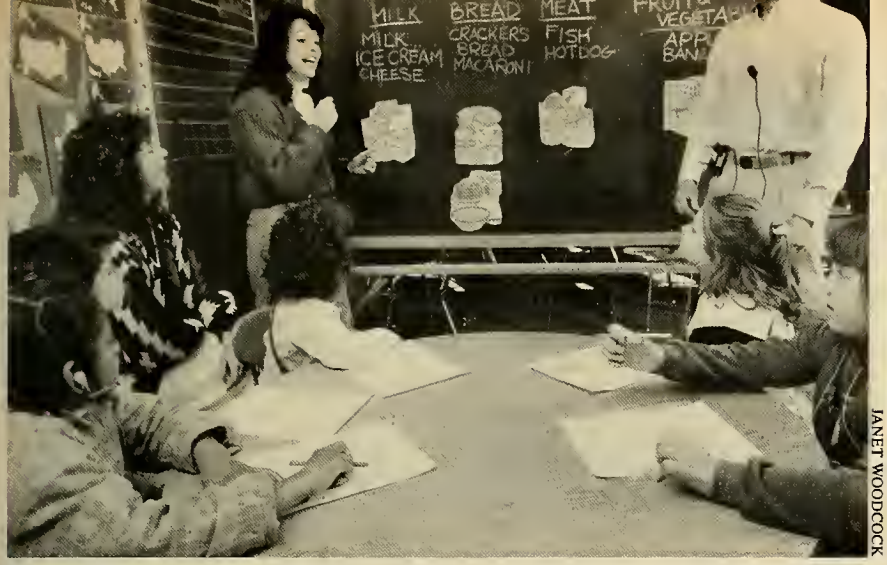
But what if the time-honored lecture and book approach were replaced by a hands-on effort? What if instead of looking at pictures of fish, the kids looked at real fish? What if they set up and maintained an aquarium? What if they visited the New England Aquarium? What if they dissected fish?

You guessed it. The kids were as happy as, well, clams. And they learned a great deal.

This teaching approach, planned and executed by Steven J. DeCoste '89 and Ian Darnell '89 at the Columbus Park Elementary school in Worcester, was an unqualified success.

And, as with most of the 50 or so projects completed each year in the "Educa-

Lance E. Schachterle oversees hundreds of school-based student projects.



JANET WOODCOCK

JANET WOODCOCK

(Top, left) Beth A. Buscher '89 and Michael J. Carroll '89 teach health science to hearing-impaired students at the Francis McGrath School. Around the table are (clockwise from left) Tiana Fisher, Daryl Martin, teacher Jane Perry-MacNeil, Heather Flynn, Alica Malick and Anna Szydlik. (Bottom and top, right) John W. Standley '89 explains photography to fourth graders at the Chocksett School.

tion in a Technological Society" division of WPI's Interactive Qualifying Project (IQP) program, that success was no accident (see "Explorations," page 47, for summaries of other projects). It was the result of an extended, well-thought-out process. Indeed, WPI students spend as much time preparing and, ultimately, evaluating their projects as they do actually teaching.

"Most of the projects deal with science or computers in the classroom," says Lance E. Schachterle, chairman of the Division of Interdisciplinary Affairs. "Students are prepared in advance to go into the classroom to test an idea or a hypothesis or a teaching method. The first step is background research into how that particular teaching methodology had been developed and used in classroom environments before."

Students working on the fish life project, for example, had studied in advance the use of hands-on projects in the classroom. In discussions with special needs teachers, they decided which scientific concepts they wanted to teach, then figured how best to demonstrate them.

"Our students begin a project knowing that whatever they do will have to be evaluated," explains Schachterle, "so they organize the teaching material in a manner that allows them to evaluate as they go. The final report contains an analytic review of how successful the project was."

To again use the fish project as an example, the effort was judged a success, not through an offhand, gut reaction on the part of the WPI students, but rather on the basis of extensive pre- and post-testing, continuous classroom observation, discussions with special education teachers and a literature review.

"We want our students to interact with classroom teachers on a semi-professional basis," says Schachterle. "What we don't want to do is simply have our students go into the classroom and take over the regular activity of the teacher. When that happens, the teacher gets bored or takes a break. It doesn't do anyone any good. One of our goals is to have the teacher learn what positive things can be done to improve the nature of classroom teaching."

For students who are about to embark on a project in special education—a popular and extensive part of the overall educational project program—one of the most important aspects of the pre-project training is an orientation on how to deal with special needs children.

"They spend an entire term in this training so that when they go into the classroom they know the law, the language and what kind of disabilities the kids have," says Schachterle. "They've done some research on the kinds of learning problems they're going to address and they can establish a rapport with the teacher."

To help prepare the students, the college hired special needs teacher John Schlichte to provide this all-important training.

Now in his third year of working with WPI students, Schlichte makes wide use of guest speakers, videos and specific examples in his 14-session orientation. His focus is on the application of technology to special needs children: modified wheelchairs, computer adaptations, special recreational equipment, or electronic teaching devices.

Depending on the nature of a student's

project, there might be discussion about devices that read books for the visually impaired, for example, or special units that allow the deaf to use telephones. Students are also required to visit special education classrooms.

As for the projects themselves, they cover a wide range of subjects and approaches.

One group of students assessed the value of working with a light box to improve handwriting, while another used sign language and other visual aids to teach health education to the hearing impaired. Still another group analyzed the effectiveness of computer-aided instruction in helping the children strengthen their mathematics skills.

"They're enthusiastic," says Schlichte of the WPI students. "And they're genuinely concerned about helping the special needs kids."

Since 10 percent of the public school population receives some kind of special needs service, there's much to be done. To plant the seeds of a long-term commitment, workshops to familiarize WPI faculty with the role of technology in special education are now being planned.

"We want to get them involved in suggesting IQP topics within their area of expertise," says Schlichte.

As impressive as they are, special education projects make up just one segment of the overall educational IQP program. The scope of the general program is extraordinary. In hundreds and hundreds of projects, students have explored topics ranging from "LOGO for Little Learners" to evaluations of WPI's own academic programs. They've developed countless computer programs to be used as learning aids and studied social environments and child development theories. They've taught science courses at virtually every level, written instruction manuals and developed curricula. They've conducted surveys and produced kits.

They've worked with school systems large and small, public and private, and with museums and science centers.

Says John van Alstyne of the teaching IQPs, "They're a natural for our students, because if you really get involved in education, you see a part of life you wouldn't ordinarily see, and you come away with a heightened sense of social issues. And it offers the college another way to be a member of the community, by helping the schools cope with more and more sophisticated education and less and less money

ROBERT S. ARNOLD

(Top) Tutors in Worcester's "Spotlight" program: (clockwise from bottom) Scott A. Dresser '89, Shawn D. Harrison '89, Anthony J. Bangrazi '88, and Lauren E. Carter '89. (Bottom) Juniors Kenneth A. Colby and Daryl A. Cote (second and third from left) designed an introductory engineering course for high school students.

JANET WOODCOCK

to do the things they want to do."

Van Alstyne points to a project conducted last semester at Auburn High School. Two junior electrical engineering majors, Daryl Cote and Ken Colby, planned and taught a complete Introduction to Engineering course.

"We covered all the major fields of engineering," says Cote, "and focused on how engineers solve problems."

The pair used film strips and plenty of demonstrations. During the segment on civil engineering, for example, they showed the students a film clip of the collapse of the Tacoma Bridge. To illustrate other disciplines, they used wrist rockets, explosions, glow sticks, and a single stage linear accelerator.

"The demonstrations were the key," notes Cote. "That's what kept them interested."

Says Schachterle: "The introduction of hands-on science into the classroom is a major part of the educational IQP program. We're trying to liven up the science curriculum in the public schools by experimenting with experiential learning, demonstrations of basic scientific principles.

The other major thrust of the educational IQPs, Schachterle says, involves computer-related projects.

"They're important," he explains, "because many of the school systems put a lot of money into hardware over the years, and not enough into people. We need to assist teachers who have not been given the time, the training or the continuous updates that are so vital.

"After our students have completed their projects, we hope that they have left something in the classroom—that they have in some fashion made the teachers more confident in using computers, given them a new way of thinking about computers and education."

Typical of such projects are several advised by mathematical sciences Professor Mayer Humi, in which WPI students taught and implemented a computer education curriculum (LOGO, elementary and advanced BASIC and utilities) in area elementary and secondary schools.

As usual, the projects began with extensive research into education and teaching methodology.

"Our objective," says Humi, "was to determine the effect of the computer curriculum on the students' development. But we also wanted to determine the appropriateness of various topics to different grade levels. And we wanted to find out the best ways to integrate the curriculum with other subjects the students were studying.

"As part of the utilities course, for example, students learned to use the editor, which in turn helped them type their English assignments. And the elementary BASIC course helped with their science and math assignments."

A related project used the computer curriculum to test Swiss psychologist Jean Piaget's theory of child development.

The result of the IQPs in that cluster was the production of several teaching manuals, and clear recommendations on how to implement a fully-integrated set of computer education courses.

According to Humi, such projects offer two-way benefits. "The schools and their students get a lot out of it, of course, but so do our students. They learn to develop their communication and organizational skills, and they get valuable teaching experience."

▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲

Other Initiatives: From COMETs to Computers

Frontiers in Science and Mathematics, the master's programs in natural science and mathematics and, especially, the undergraduate student projects, all add up to an imposing assault on the problems facing precollege education.

But they represent just a portion of the many activities associated with the school/college collaboration center. Additional programs provide role models for minority students, enrichment for able youngsters and seminars for secondary school mathematics teachers:

Originally introduced in 1986, Career Opportunities Merging Education and Technologies (COMET) has as its long-term goal the establishment of a qualified pool of minority students. [See *WPI Journal*, Spring 1988.] WPI students, supervised by Prof. Susan Vernon-Gerstenfeld,

MICHAEL W. DORSEY

High school students compete in the WPI Invitational Mathematics Meet.

spend two days each week tutoring Worcester-area high school students. While they help with such nuts and bolts as homework and English language skills, the WPI students also serve as role models.

Vernon-Gerstenfeld hopes eventually to expand the program's geographical boundaries and to focus more on the middle schools. "We want to generate interest in careers in science and technology. If we can get to them by the seventh or eighth grade, we have a better chance to foster that interest. What we've found is that with high school juniors, it's often too late—they're looking to get out, and we want to get them when they're looking to get in."

COMET was originally funded by grants from the Massachusetts State Board of Regents and General Telephone and Electric (GTE).

Pride and Enrichment for Able Kids (PEAK) is a state-funded program for gifted elementary school children in the Worcester Public Schools. "Spotlight" is a follow-up program for seventh and eighth grade "graduates" of PEAK. While both Lance Schachterle and John van Alstyne have served on the PEAK advisory board, and some PEAK-related IQPs have been completed, the college's main focus currently is on the Spotlight program.

The overall program, now in its third year, is a wide-ranging collaborative effort funded through Worcester State College. At a variety of locations throughout the city, participating students take courses in such subjects as theatre arts, photography and paleontology. At WPI, they learn about computers.

On Saturday mornings during the school year, a group of about 15 Spotlight students gather in the personal computer lab on campus to study with WPI computer science majors.

"The kids are all bright, but their experience with computers varies widely," says Scott Dresser '89, who runs the program from the WPI end. "Some have never done any programming, while others are doing the kind of advance programming I didn't do until I was a sophomore in college."

Linda DeNittis, who directs the overall Spotlight program, says the WPI effort has "worked out great." Dresser concurs: "Before it began, I thought I'd have discipline problems, but the kids are all mature and attentive."

In a related effort, WPI undergraduates, under the direction of Robert E. Connors, associate professor of chemistry, are putting the finishing touches on a program to computerize PEAK's record-keeping system.

In the fall of 1988, WPI began a new program that brings secondary school mathematics teachers to campus to teach courses, take courses, attend seminars, advise student projects and direct the new WPI Invitational Mathematics Meet. Marie Tangney of Worcester's Doherty Memorial High School was selected to be the first visiting scholar.

Last October, the college hosted the inaugural Mathematics Meet. Four-person teams from 47 high schools competed for individual scholarships and team awards. While on campus, they also had a chance to learn more about educational and career opportunities in mathematics.

Edward N. Clarke, director of WPI's Center for Solar Electrification, travels to regional elementary and secondary schools throughout the year to preach the gospel of solar electricity, particularly its application to solar-powered cars. [See *WPI Journal*, Spring 1988.] Part of his intent is to show young people the excitement of science and engineering. His audiences include children in the PEAK program.

Recognizing that classroom learning constitutes just part of a child's overall growth, undergraduate projects work with young students on a number of other levels. One group of IQPs helps the troubled youths of Worcester's Juvenile Courts, for example, while another analyzes social approaches to pre-college science and technology education.

Many departments on campus interact with area teachers on an ongoing basis, sponsoring symposia and offering educational software evaluation.

WPI's first visiting mathematics scholar, Marie Tangney.

MICHAEL W. DORSEY

▲ ▲ ▲

Epilogue

Last October, in auditoriums, gyms and classrooms across the nation, high school students sat down to tackle the Preliminary Scholastic Aptitude Test (PSAT), a version of the SAT generally taken during the junior year by students who wish to qualify for National Merit Scholarships.

The students who take the test are asked to check boxes to indicate the fields in which they may major once they reach college. Each year, for the past several years, the percentage of students who check the engineering boxes has gone down. This academic year, the total who checked engineering fell in Massachusetts to 7.7 percent, down from 12 percent in 1984 and 8.2 percent in 1987. Interest in computer science fell to 1.8 percent, a 46 percent drop since 1987. Interest in the biological sciences and mathematics also fell, to 2.2 percent and 0.6 percent, respectively.

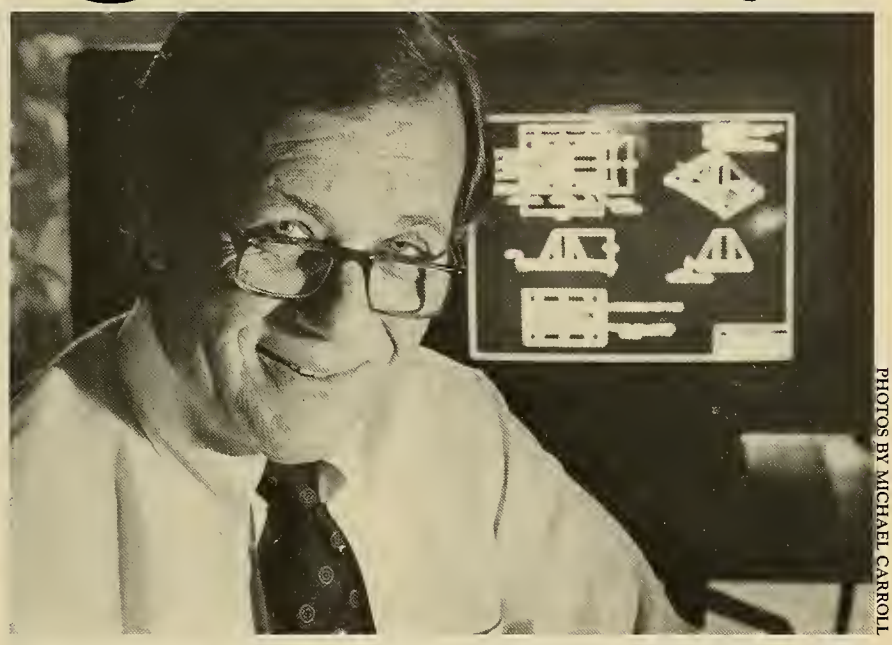
What is especially troubling is that these trends run counter to history, according to Dean Grogan. In previous cycles, students flocked to technical fields when the economy was on an upswing. But in recent years, interest in engineering and science has been dwindling at the same time that job prospects in these fields have been growing.

"There are two important messages in these numbers," Grogan says. "For industry and for our nation's competitiveness, the numbers point to the major challenges that lie ahead. But, for students who persevere in math and science, they represent enormous opportunities.

"Last year I spoke to several hundred high school students who visited our campus. Here was a select group of students who had done what many of their peers had not: they had prepared themselves for careers in science and engineering. My message for them was simple: 'You are the most important people in America.' "

Seizing the Day

By Amy Zuckerman



PHOTOS BY MICHAEL CARROLL

How did Gerald Finkle '57 build Wachusett Molding Company into a leader in the plastics industry? It was not through ambition, he says, but with discipline, guts, a love of the tinkerer's art and an ability to make the most of opportunities.

It was 1961 and Gerald Finkle '57 was sitting across a desk from Otto Morningstar, owner of the Cambridge-based Morningstar Corp., a manufacturer of plastic containers for the cosmetics industry.

Morningstar asked Finkle to set up a new operation for him that would explore novel ideas in engineering plastics. He promised to provide Finkle with the capital and the facilities to do the job.

At home that night, as Finkle contemplated Morningstar's offer, he thought, "Why not do this for myself?"

With $1,800 accumulated from family, friends, bank loans and his own savings, Finkle set up a small manufacturing plant in West Boylston, Mass., specializing in custom-molded plastic components for the industrial, commercial and medical industries.

Finkle called the company Wachusett Molding Corp. "It was an old Indian name," he notes, one that happened to be attached to the reservoir down the street and a mountain several towns over. Although he's wondered from time to time whether he might have chosen a better name, Finkle has never regretted his decision to strike out on his own.

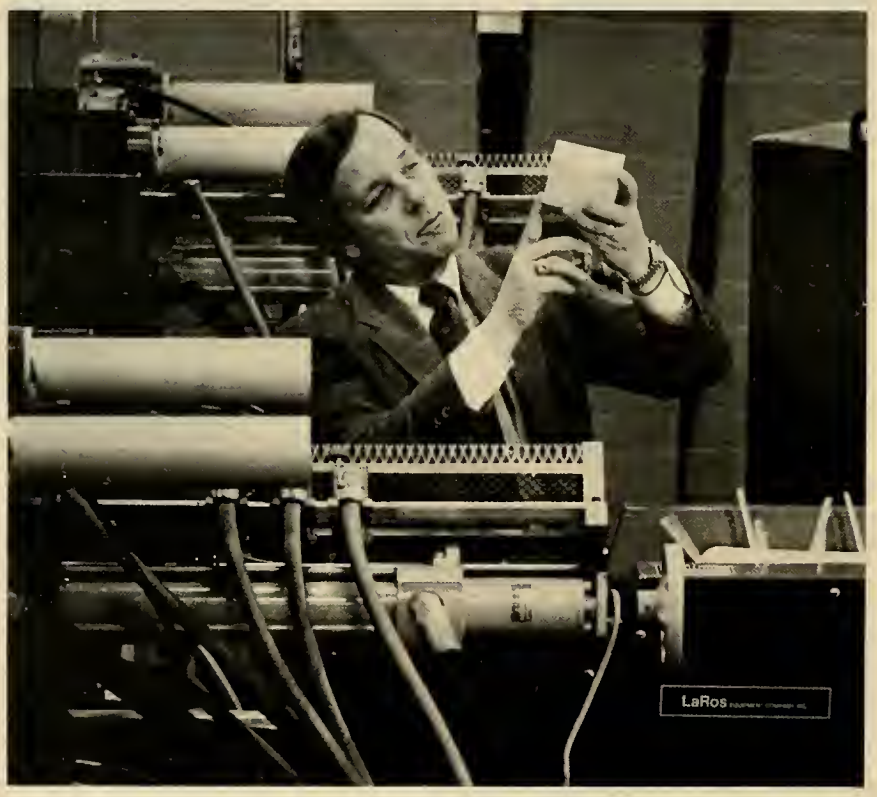
A consummate entrepreneur, Finkle has taken Wachusett Molding from a one-man operation to a company employing 65. Besides the original West Boylston plant, Finkle now runs a branch operation in Worcester and has established a new design division. Gross sales for this privately held company average $8 million annually, he says.

A good-humored man, Finkle says he never imagined himself as an industrialist when he was growing up in Clinton, Mass. His blue eyes twinkle when he relates that a WPI professor once told him he should have been a Cadillac salesman.

Yet, as he looks back, Finkle can see that he has always been "an idea person," one with a natural entrepreneurial bent and a talent for tinkering. Even before he had a driver's license, Finkle spent hours in the yard of his family home repairing old cars. He would also cajole the used car salesmen in town to send him their automobiles for waxing.

Despite these inclinations, Finkle didn't start out to become an engineer. In fact, while in high school, he thought about studying dentistry. He credits his high school principal, Eben Cobb, for his decision to pursue engineering. Cobb, an admirer of WPI, convinced Finkle and seven

In the early years, Finkle ran Wachusett Molding alone. "I didn't care a lot about money," he remembers. "I got more satisfaction out of accomplishing something; making something work. The money I made was a bonus."



other students from Finkle's class to apply to the college.

From the time he arrived in Worcester, Finkle says he was anxious to get on with life. In fact, he remembers, it was largely his love of tinkering that led him to opt out of dentistry. Preparing for that profession would have required eight or nine years of schooling, and he was not interested in putting off his professional life that long.

At WPI, where he was a mechanical engineering major, Finkle says he learned that he was an "engineer first" and that being an engineer required discipline. "You had to attend class or flunk," he remembers, "no matter what your grade average was. That type of discipline doesn't go away. And, it's an important part of entrepreneurship."

In the 1950s, WPI offered a heat and power emphasis as part of its mechanical engineering program. Finkle chose this concentration and it led to his first job, as an applications engineer with Eliot Co. in Pennsylvania, a manufacturer of steam equipment.

After a year in that position, he joined the Eliot sales office and went on the road. Although he quickly became bored with learning to "pick a territory clean," Finkle would later find the experience invaluable when it came time to run his own company.

In the late 1950s, when plastics manufacturing was still in its infancy, Finkle decided it was the field for him. While talking to friends in Clinton he learned of an opening at a local company called Nylon Products Corp., which would later grow into a major plastics producer called Nypro. The job, as chief engineer, was short-lived, but it gave Finkle some valuable experience that would help him shape his own plastics manufacturing operation.

Looking out at Wachusett Molding's manufacturing plant today from the window of Finkle's modern, second-story office, or watching the hustle of engineers in the offices below, it's hard to imagine the early days of Finkle's company when he worked alone, largely as a subcontractor, pushing out windshield scrapers and other plastic items by the millions.

Those were tough times, Finkle remembers, when the thrill of creating his own products and the joy of exploration were offset by back-breaking, mind-numbing work that sometimes required him to tend his machines through the night.

In those early days, money wasn't Finkle's primary concern. "I didn't care a lot about money," he says. "I got more satisfaction out of accomplishing something; making something work."

During Wachusett's first 15 years, Finkle concentrated on making plastic components that could replace components made from other materials, particularly metal. This was low-volume work, he says. But about 12 years ago, Wachusett entered the medical diagnostics market, where the volumes are measured in the millions.

This change in direction came about by chance when one of his salesman acquired an account for the production of disposable tubes and vials. Finkle says he "seized the opportunity to enter the medical field in a big way."

Wachusett Molding was an early player in the medical diagnostics game, which accounts, in part, for the fact that today the company is the leader in the field. But much of the firm's success can also be attributed to new manufacturing techniques devised by Finkle—such innovations as the utilization of runnerless molding and the automatic removal of parts from molds, which enables one worker to simultaneously run eight or more machines.

With the introduction of computerization, Finkle was able to turn out products

Finkle, here examining a tape dispenser made in Wachusett's Worcester plant with Donald Pellegrin, maintenance manager, says Wachusett has succeded by exploiting specialized niches in the plastics industry.

for the medical industry— primarily small, disposable items molded in styrenics, polyolefins and a variety of engineered thermoplastics—at a much lower cost and with much higher levels of quality than could any of his competitors.

Finkle took the experience gained with these products and applied it to a variety of high-volume consumer and health care items, everything from deodorant containers and glue sticks to pen barrels. By now, Finkle says, he had decided that Wachusett would specialize in high-volume work.

Then, about five years ago, Finkle realized it was time to focus on marketing. "Our growth had been solid, but not spectacular," he notes. "We looked at the company harshly and realized we weren't doing a good job of selling ourselves."

Part of the problem, he says, is that all of the top people at Wachusett Molding were engineers. Words like image, talent and advertising were simply not in their lexicon.

With the assistance of professional marketing consultants and a $75,000 budget, Finkle and his staff defined two main objectives for the company. The first was to double the company's sales volume, then about $5 million, while maintaining or improving the profit margin on sales. The second was to increase productivity.

The initial step, as outlined by the consultants, was to identify the industries that use small precision parts in high volumes. These turned out to be firms that make medical devices, personal care products, product packaging and hardware. Most of these were concentrated along the Eastern Seaboard, the Midwest and the West Coast.

To reach these firms, Wachusett mounted a direct-mail campaign, ran full-color advertisements in plastics industry and trade magazines, created a monthly newsletter featuring articles on molding technology, produced videotape presentations highlighting the capabilities of the company's manufacturing plant, and introduced a computer system that streamlined everything from taking orders to controlling the manufacturing plant to shipping products.

That first marketing strategy was so successful that Finkle is in the process of devising a second one. Working again with targeted marketing, Wachusett Molding will concentrate this time on selling the company's "unique capabilities" in the personal product market he says. Wachusett Molding, he says, is one of the few companies that can mold parts and deco-

In the decorating facility at the Worcester plant, Finkle goes over plans with Robert Stoner, shift supervisor. "Be bold," he advises prospective entrepreneurs. "It takes guts."

rate them in the same facility, saving time and money.

Offering an example, he holds up a small, white box. At first glance it resembles the metal bandage boxes that are fixtures in just about everyone's medicine cabinet. Closer examination reveals that the box is indeed plastic.

What he has done for this product, Finkle promises to do for "lots of packaging. It's not just a matter of having the printing and molding equipment in the same area. It's a matter of having the right skills."

Of his most recent accomplishments, the one that Finkle is most proud of is his Designex division, which he started about three years ago with the purchase of a sophisticated computer-aided design system. Although he has designed products for customers for many years, Finkle says it has never been one of his company's major concentrations. But with Designex, Wachusett salesmen can now solicit ideas in the field and take them back to West Boylston, where Finkle and his engineers implement them.

"We don't create ideas," he notes, "we execute them. We design to manufacture efficiently."

One of the first major products to come out of Designex is an ovulation and pregnancy test kit marketed by First Response. Finkle says the division recently completed a design for a contact lens manufacturer and is working on commercial products, such as tape dispensers.

As he looks back on his 27 years in business, Finkle says his success has exceeded all of his early expectations. With a larger sales volume and an expanded product line, Wachusett Molding might possibly be a bigger company today, he notes, but Finkle says he doesn't measure success in those terms.

"I'm just not that ambitious," he says. "A lot of entrepreneurs think work is everything. But I love to create things. Our growth has not been a result of being aggressive, of being out there pushing. We've grown by seizing opportunities."

His advice to future entrepreneurs is simple. "Be bold," he says. "Don't be afraid. It takes guts, so if you're fearful don't do it."

Finkle thanks WPI for training him to be a "good communicator." When it comes to running a business, even a manufacturing concern, he says communication skills are just as important as engineering ability.

That's not to underestimate the value of engineering training, he notes. Finkle says he learned the value of his WPI education within a few months of graduation. As part of his first job he was supposed to tour a factory on a daily basis and learn how to use the equipment. Finkle was reprimanded for skipping this assignment.

"I told the supervisor that not only had I already worked on the equipment, but we had actually tested it at WPI. That afternoon I was appointed training manager for the rest of the group."

Finkle also praises WPI for giving him a practical education, one that has enabled him "to really do things."

"It's been invaluable to me," he says, "especially in running my own business. Not only do I know how to design, but I know the limitations of the manufacturing process. Not only did I learn engineering logic, but I took away a lot of nuts and bolts things that have proved invaluable."

Despite the success he has realized over the years in the plastics industry, Finkle says there are still days when he wonders whether he might have been better off in dentistry. On those days he calls a dentist friend who reminds him, as he has for many years, that dentistry can be boring. In fact, the friend always adds, he would love to run a company like Wachusett Molding. Finkle says he always feels relieved as he hangs up the phone, for the last thing he ever wants to be is bored.

Zuckerman is a free-lance writer based in Shrewsbury, Mass.

Stellar Performances at Chocksett School

Interactive Qualifying Project by John P. Sonia Jr. '89 and Steven R. Wold '91.
Advisors: Robert A. D'Andrea, associate professor of civil engineering; and Joseph D. Sage, professor of civil engineering.

At the Chocksett School in Sterling Mass., there are glow-in-the-dark stars on the ceiling of the associate principal's office. A group of fourth graders there made "constellation projectors" out of cardboard tubes and flashlights, and took over the gym to demonstrate the relationships between the planets.

Innovative techniques, energetic teachers and enthusiastic students have characterized a program in Earth science that Wold and Sonia created for gifted and talented students in Chocksett's Differentiated Learning Program.

The two WPI students designed an astronomy and geology curriculum and are creating a manual for teachers that will include background information about both subjects, detailed descriptions of activities and a list of materials teachers will need to mount the course.

Eight boys and girls are participating in the program this year. So far they have learned to find stars, planets and constellations with a star wheel; read myths about the constellations; built telescopes out of paper towel tubes and lenses; and used an eight-inch telescope that Wold and Sonia borrowed from James P. O'Rourke, professor of electrical engineering and director of the WPI Observatory.

One evening last December, Sonia and Wold invited the children, their families and friends to join them in the field next to the school to observe and sketch the objects they saw through the telescope. Later, the children gathered in the gym where they arranged themselves into a scale-model of the solar system with the sun represented by a three-foot yellow balloon.

In the geology unit, students are identifying rocks and minerals and learning basic theories and explanations of geological formations. Sonia and Wold say they hope also to "simulate a volcano, grow crystals with laundry detergent and salt, and try to create snow."

Darryl Hoff of the Center for Astrophysics—Harvard College Observatory, helped locate instructions and materials for the course. Hoff says 80 percent of his colleagues became interested in the scientific world through exposure to astronomy as children.

Sonia says the children have enjoyed the project. "Our goal is to get them interested in astronomy and geology, not just to memorize facts. We're giving them a way to investigate these things and draw scientific conclusions."

Patience, Communication Make Math Easier

Interactive Qualifying Project by Kevin J. Daul '89, Peter R. Fournier '89 and Jeffrey A. Johnson '89.
Advisor: Mayer Humi, professor of mathematical sciences.

Communication, according to the dictionary, is simply a process of exchanging information through signs, symbols or behavior. Anyone who's ever struggled through long division or algebra knows that when it comes to mathematics, communication isn't always that simple.

For their project, Daul, Fournier and Johnson reviewed more than 20 years of educational publications to develop an appreciation for the challenges teachers face in communicating mathematical concepts to their students. They also gained an understanding of the importance of lessons that enable children to use what they have learned to solve more difficult problems.

The team put its research to practical use tutoring sixth-, seventh- and eighth-grade math students at Yeshiva Academy in Worcester. Working one-on-one or in small groups, they dealt with problems typical of any classroom: students who had trouble understanding particular concepts or lessons; inattention; lack of motivation; and low self-confidence.

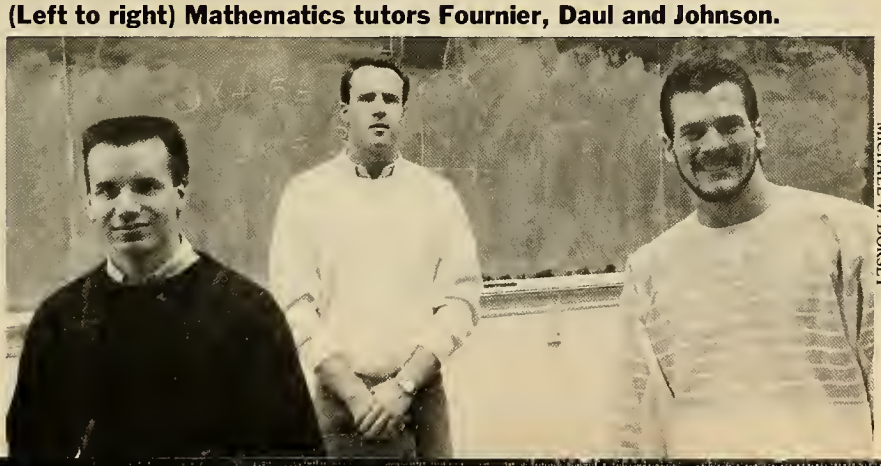
Daul, Fournier and Johnson say they learned that the ability to translate concepts into language students can understand is a major factor in successful teaching. Once they stopped "thinking in terms of calculus," they saw the quality of their teaching improve dramatically.

Yeshiva Academy mathematics teacher Karen Koza says, "Some students went in already confident of their abilities, just needing to get a feel for the methods. Others had a history of negative attitudes toward math.

"The improvements in the students were twofold: one was a gain in confidence in their ability to perform the basic tasks; the other, a more measurable change, was an improvement in their test scores."

The WPI team recommended that a stricter grading policy, stronger emphasis on mathematics and a curriculum geared to challenging bright math students be implemented not only at Yeshiva Academy, but across the nation.

(Left to right) Mathematics tutors Fournier, Daul and Johnson.



MICHAEL W. DORSEY

FINAL WORD

The Magnetic Laboratory Keeps Its Secrets

Protected on one side by a steep hill, and enshrouded by the linked branches of a semicircle of tall pines on the other three, the tiny stone building is virtually invisible from the busy intersection of Institute Road and Boynton Street where it has stood since 1887.

Invisibility is an appropriate fate for the Magnetic Laboratory, as the little building was originally named. For most of its history, it has been a place where people have gone to work or meet in private. Its original purpose was "to afford facilities for conducting the most delicate electrical experiments," according to an unpublished account by Zelotes W. Coombs, one of WPI's early professors of English.

Theories of electricity and magnetism popular in the late 19th century required that the structure be built completely without iron. To save money, architect Stephen C. Earle was also asked to make the building quite small. While the laboratory is faithful to the Romanesque Revival style popular during the period, Earle let his imagination leap with this structure, which is reminiscent of a folly—a whimsical building, common in 18th-century England, which was often meant to be a conversation piece, to commemorate a person or event, or to lend interest to a view.

Constructed of Millstone granite trimmed with Longmeadow sandstone, the laboratory consists of a one-story room measuring 15 feet by 20 feet. Above the room is a pyramidal roof and an adjacent turret topped by a conical "hat."

"The axis of the main part of the building coincided with the magnetic meridian, and through opposite windows in the tower passed the north and south meridian," Coombs wrote. "It was connected by heavy wires with the Salisbury Laboratories."

"Electricity in the 1880s was very little understood," Mildred Tymeson reported in *Two Towers,* WPI's centennial history. "The class of 1886 had given a few sockets and light bulbs to the school, but they had not been installed. The school was still lighted by gas lamps, and the streets stuttered with a sporadic system of carbon arc lamps. . . . students invariably took off their watches before entering any room where there was known to be a motor."

Few accounts remain of the experiments conducted inside, but theses written during the period indicate that scientists worked with such instruments as a galvanometer, used to measure electrical currents; a Rowland dynamometer, described as "essentially a galvanometer with a very sensitive wire for suspension of the voltage coil"; and an electrostatic voltmeter, which depended "upon the principle of repulsion of two bodies similarly charged to the same potential."

Although the site had been chosen to be as free of vibrations as possible so as not to disturb the delicate instruments, the installation of street railway lines along Boynton Street in 1888, and the electrification of the trolleys three years later, doomed the laboratory building. The quivering made observations virtually impossible except in the hours after midnight when the line was not in use, and the lab was soon closed.

The structure remained idle until about 1901 when it became home to a 500,000-volt transformer. The device was used by the Electrical Engineering Department for high potential experiments until 1907 when the department's new home, Atwater Kent Laboratories, was constructed. For several years beginning in 1911, the Magnetic Laboratory served as headquarters for the WPI student newspaper, *Tech News.*

During 1917 and 1918, WPI graduate and rocket pioneer Robert H. Goddard, then a physics professor at Clark University, conducted experiments in the laboratory, which was remodeled to include a miniature machine shop. The building's tower was equipped for drafting and cartridge making.

Goddard was determined to maintain the secrecy of his work. In his diary he included a letter noting "the probable great military value of this rocket, [and the recommended] appropriation of $10,000, in addition to the $2,500 now available" to fund the research. "In the interest of secrecy, I have installed a private, nonlisted telephone in the building [and] I believe that we should also have a day and a night watchman, armed, as soon as we begin serious operations," he wrote.

Mystery has always surrounded WPI's Magnetic Lab (opposite). Today, an eerie skull greets visitors.

Goddard's experiments were not only secret but dangerous. An article in the June 15, 1920, issue of *Tech News* recalls that the explosions resounding from within would often cause those on Boynton Hill to poke their heads out their windows and "look around for the remains of the professor."

In 1921 the laboratory was remodeled for the last time to become Skull Tomb. Skull, WPI's senior honor society, is open only to members, and the building's windows have been securely sealed to make it impossible to see inside. Today, the building is a ghostly edifice with a skull affixed to its front door. It is a mysterious fortress that attracts the interest of those who glimpse it through the curtain of dense pines; but, like those who have occupied it over the last century, the venerable laboratory reveals few of its secrets.

—Bonnie Gelbwasser

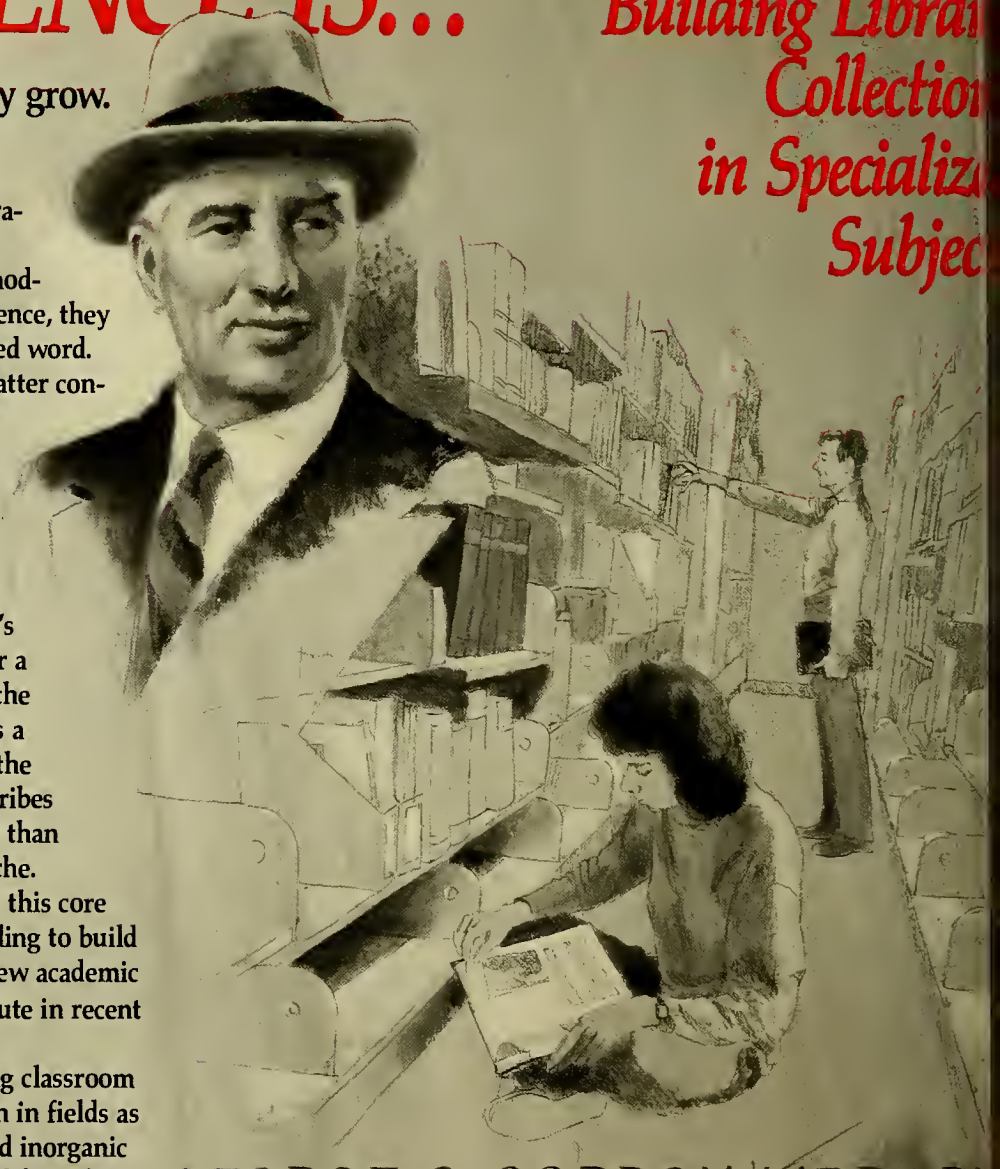
Gelbwasser is assistant director of the WPI News Service.

JANET WOODCOCK

EXCELLENCE IS...

Building Libra Collectio in Specializ Subjec

Libraries are not made; they grow.
—*Augustine Birrell*



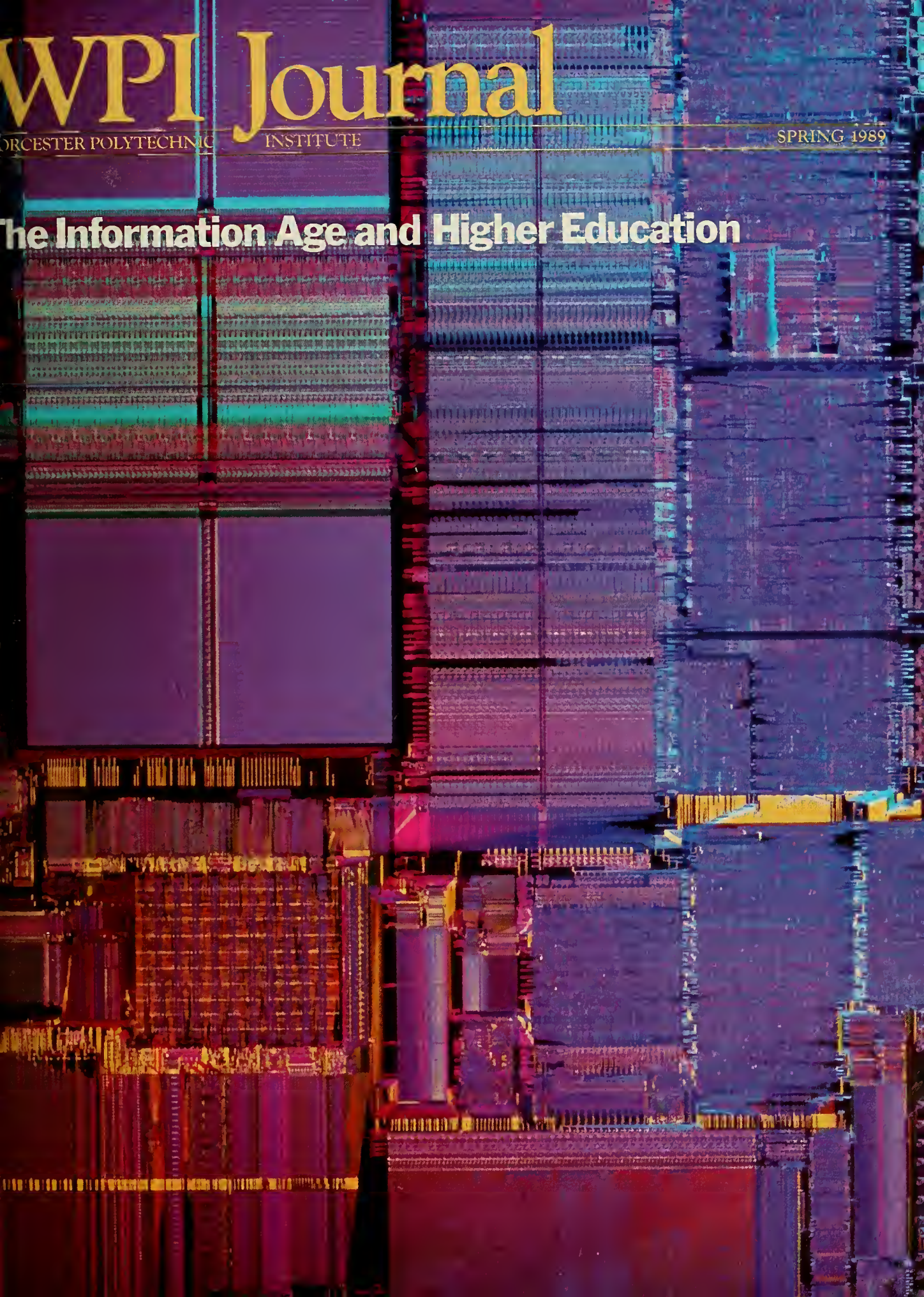
While computers, sophisticated laboratory equipment and state-of-the-art classrooms are part and parcel of a modern education in engineering and science, they cannot replace the value of the printed word. Books, journals and other printed matter convey knowledge in a unique, intimate manner. Print gives students the opportunity to explore new ideas and expand their understanding in ways that lectures and laboratories cannot.

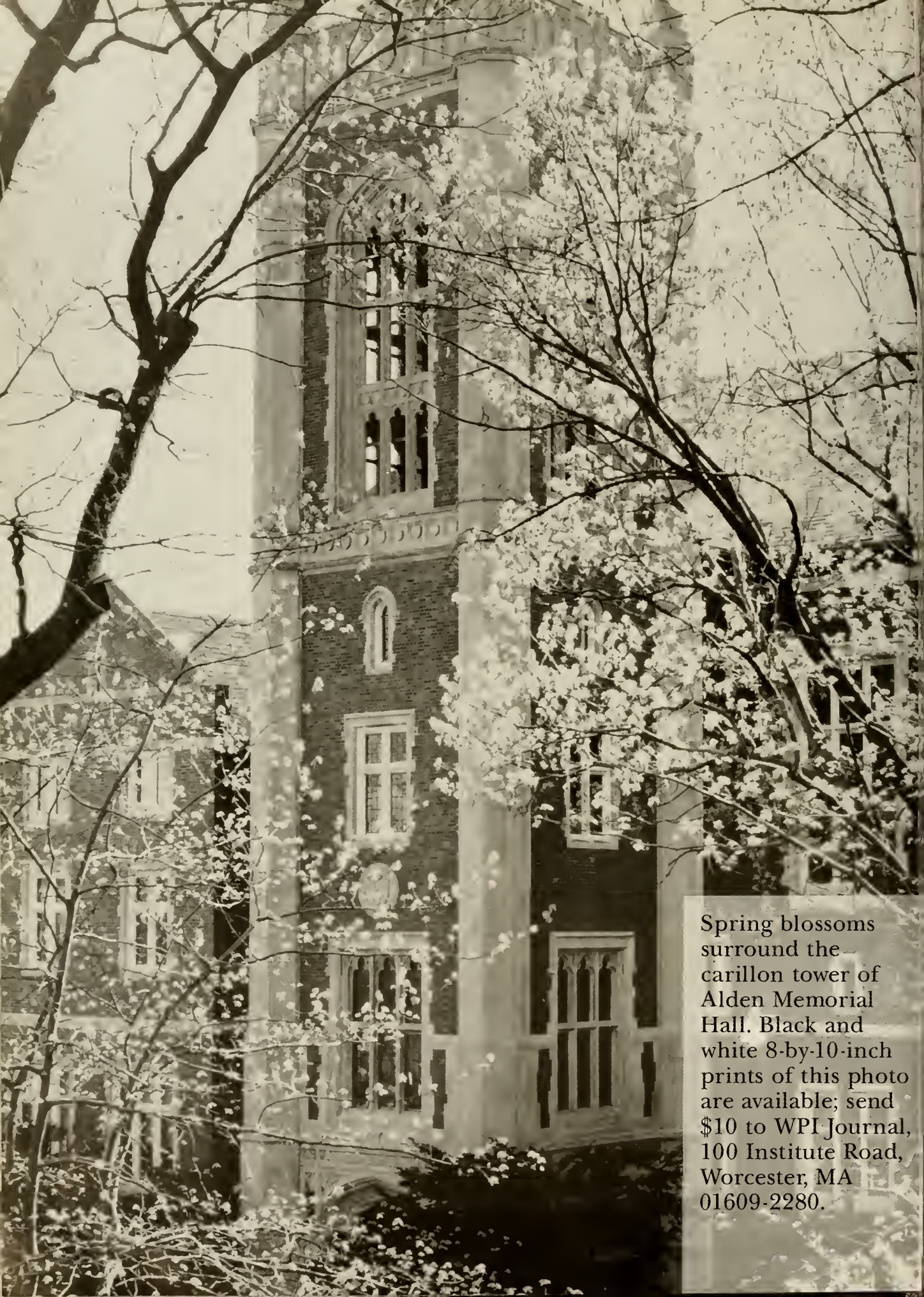
To support the education of WPI's students and provide a foundation for a growing body of scholarly research, the George C. Gordon Library maintains a good working collection. Currently, the library holds 270,000 volumes, subscribes to 1,400 periodicals and houses more than 760,000 technical reports on microfiche. While the library continually adds to this core collection, WPI needs additional funding to build specialized collections in the many new academic areas that have emerged at the Institute in recent years.

Students and faculty are pursuing classroom studies, projects and original research in fields as diverse as biomedical engineering and inorganic membranes, artificial intelligence and firesafety, biotechnology and computational mechanics, and microelectronics and social ethics. But the library's acquisition rate in these and other areas is inadequate to maintain excellence in these fields.

Funding specialized collections at the Gordon Library—whether providing money to purchase new books, supporting the ever-rising cost of journal subscriptions or funding named collections or libraries in specific subject areas—offers donors a special opportunity to remember loved ones with a truly living legacy, one that will continue to influence and inspire future leaders, and thinkers, for many years to come. As Henry David Thoreau wrote in *Walden*, "Books are the treasured wealth of the world and the fit inheritance of generations and nations."

Support the Campaign for Excellence


WPI Journal
ORCESTER POLYTECHNIC INSTITUTE
SPRING 1989
The Information Age and Higher Education



Spring blossoms surround the carillon tower of Alden Memorial Hall. Black and white 8-by-10-inch prints of this photo are available; send $10 to WPI Journal, 100 Institute Road, Worcester, MA 01609-2280.

WPI JOURNAL

VOLUME XCII NO. 2
SPRING 1989

CONTENTS

2 The Information Age Goes to College *Lee David Goodwin*

How will the information revolution shape the colleges of tomorrow? Nine experts offer their views.

9 Calculated Risk *Amy Zuckerman*

Computers, concepts and real-life problems are the ingredients of a new calculus curriculum.

I Equal to the Task *Lisa Hooker*

Classroom teachers try some unusual tactics to win the war on mathematics illiteracy.

VI Oh, for a Book and a Shady Nook *Leslie Brunetta*

Summer reading from 'round the world.

XII Sequestered in Suburbia *Sue De Pasquale*

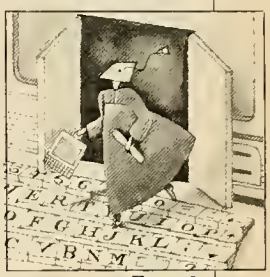
Today's lifestyles and work patterns are changing the nature of suburban neighborhoods.

29 Curiouser and Curiouser *Virginia L. Woodwell*

As it marks its 20th anniversary, the Computer Science Department becomes a center of state-of-the-art research.

35 Computer Architecture *Shirley Standring*

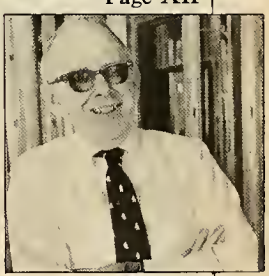
In progress: The George F. Fuller Laboratories, a stunning new home for the information sciences.



Page 2

Page 9

Page XII



Page 29

DEPARTMENTS

38 **Inside WPI:** Introducing the Salisbury Scholars. *Michael Dorsey*

39 **Memory Bank:** A life rich in firsts. *Roger N. Perry Jr.*

40 **Final Word:** New life in the old mill. *Ruth Trask*

Staff of the WPI Journal: Editor, Michael W. Dorsey • Alumni Information Editor, Ruth S. Trask

Alumni Publications Committee: Samuel Mencow '37, chairman • Paul J. Cleary '71 • James S. Demetry '58 • Judith Donahue, SIM '82 • William J. Firla, Jr. '60 • Maureen Sexton Horgan '83 • Carl A. Keyser '39 • Robert C. Labonté '54 • Roger N. Perry Jr. '45.

The WPI Journal (ISSN 0148-6128) is published quarterly for the WPI Alumni Association by Worcester Polytechnic Institute in cooperation with the Alumni Magazine Consortium, with editorial offices at the Johns Hopkins University, Baltimore, MD 21218. Pages I–XVI are published for the Alumni Magazine Consortium [Johns Hopkins University, Villanova University, Western Maryland College, Western Reserve College (Case Western Reserve University), Worcester Polytechnic Institute] and appear in the respective alumni magazines of those institutions. Second class postage paid at Worcester, MA, and additional mailing offices. Pages 1–12, 29–40 © 1989, Worcester Polytechnic Institute. Pages I–XVI © 1989, Johns Hopkins University.

Staff of the Alumni Magazine Consortium: Editor, Donna Shoemaker • Wrap Designer and Production Coordinator, Cecily Roberts • Assistant Editor, Sue DePasquale • Consulting Editors, Alan Sea and Elise Hancock • Core Designer, Cecily Roberts.

Advisory Board of the Alumni Magazine Consortium: Johns Hopkins University, B.J. Norris and Alan Sea • Villanova University, Eugene J. Ruane and D.M. Howe • Western Maryland College, Joyce Muller and Sherri Kimmel Diegel • Western Reserve College, David C. Twining • Worcester Polytechnic Institute, Michael Dorsey.

Acknowledgments: Typesetting, BG Composition, Inc.; Printing, American Press, Inc.

Diverse views on subjects of public interest are presented in the magazine. These views do not necessarily reflect the opinions of the editors or official policies of WPI. Address correspondence to the Editor, The WPI Journal, Worcester Polytechnic Institute, Worcester, MA 01609-2280. Telephone (508)831-5609. Postmaster: If undeliverable please send form 3579 to the address above. Do not return publication.

Cover: The i486, a new microprocessor from Intel Corporation containing 1 million transistors, is indicative of the sophisticated technology that has made the Information Age possible. Story on page 2. Photo courtesy Intel Corporation.

The Information Age Goes TO COLLEGE

The wired university—what many call the college of tomorrow—is coming, but not as fast as today's technology could make it happen. For while computers get faster, smarter and more powerful every year, human nature is much slower to change.

That's the message delivered by the information industry executives and innovators who share their views on information technology and higher education with *WPI Journal* readers in the pages that follow.

Computers have already had a significant impact on higher education. Their speed and power have made many tasks easier—from writing term papers to maintaining university library catalogs to modeling complex physical phenomena. But they have not greatly altered the core of the educational process—the transfer of knowledge from instructor to student.

"The word processor we have today is the kind of thing that 1,200 scientists shared 20 years ago because it was so expensive. Now secretaries each have their own.''

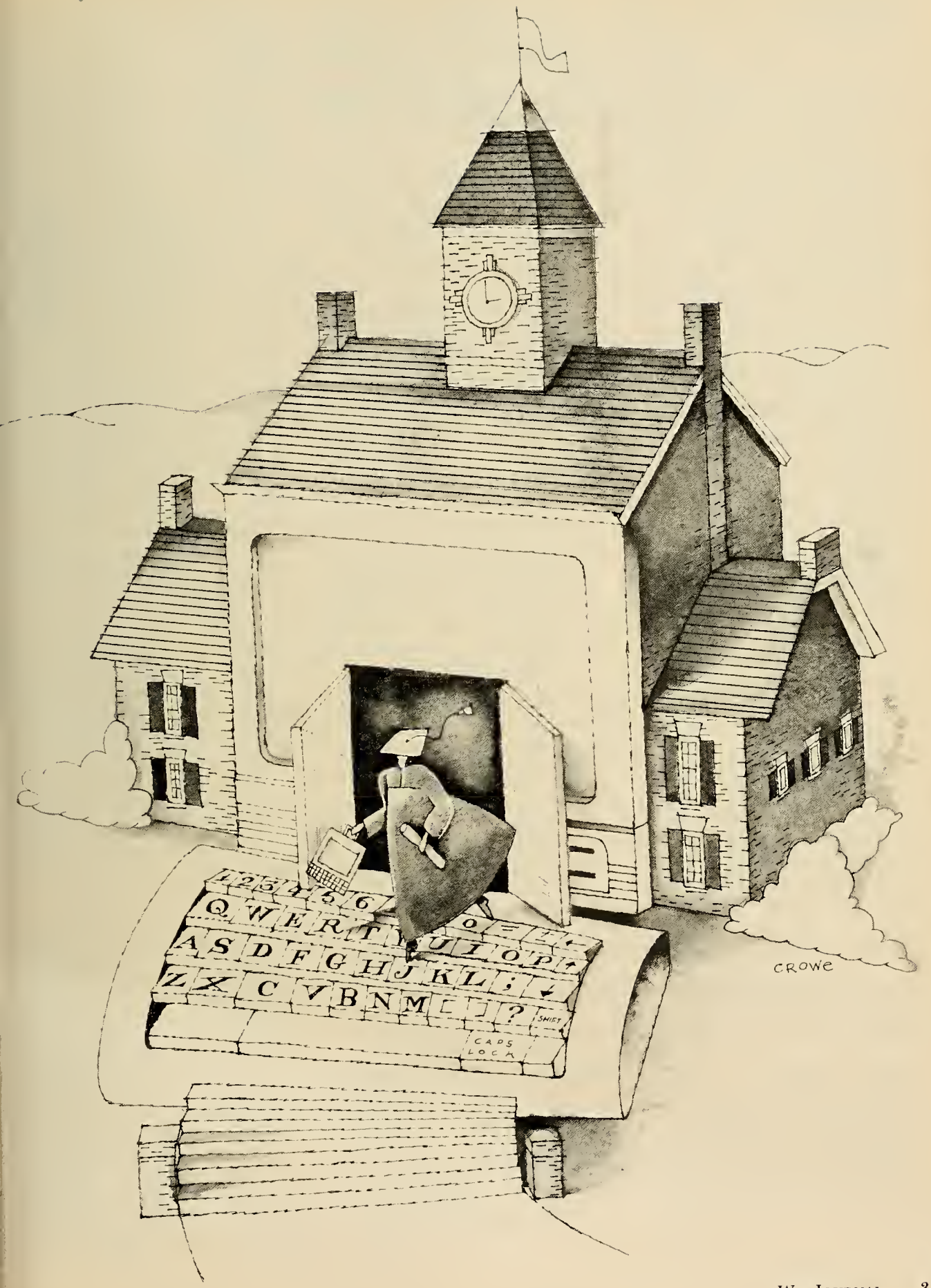
—Ralph Gomory

Despite advances in computer architecture, the widespread use of personal computers (PCs) and powerful workstations, and the introduction of high-speed data networks, the value of the classroom experience will likely remain unchanged, these experts say. And, they note, the mere introduction of information technology doesn't necessarily mean that education—or any other process—will get better or more efficient.

The thoughts you will read below include those of Ralph Gomory, senior vice president for science and technology at IBM, who recently delivered the Commencement address at WPI's 121st graduation exercises. Also represented are Andrew Grove, chief executive officer of Intel Corporation; Kenneth Fisher, president and chief executive officer of Encore Computer Corporation; and John Shields, senior vice president of Digital Equipment Corporation. All, along with Gomory, received honorary degrees at WPI's recent Commencement, the theme of which was, "The Information Age: Its Implications for Higher Education."

In the following pages, they and five other leaders of the information age size up the information technology of tomorrow and the role it might play at the colleges of tomorrow. Their comments constitute a mixture of advice for today's educators and a vision of what education will be like in the 1990s and beyond.

By Lee David Goodwin


Q W E R T U I O P
A S D F G H J K L ;
Z X C V B N M ? SHIFT
CAPS LOCK
CROWE

Ken Fisher, chairman, president and chief executive officer of Encore Computer Corporation

What developments in computer technology will impact education in the years ahead?

I see the "client-server" style, where everyone gets his own computer and access to a lot of power with it, as the dominant trend over the next five-to-10 years.

Engineers used to carry slide rules, then they carried calculators and then they used terminals. Now we're going to put the power on the desk—in a workstation—and back it up in a central location. This central computer, the "server," standing behind the workstation, will be the next big tool for serving clients. Where the power will reside (in the server or the client's workstation) will be a question of economics.

From a technical point of view, we're going to solve problems in the future by incorporating parallel processing in computers. It won't be important for everyone to learn the techniques of parallel processing computing, though, because they'll be transparent to the user.

What is parallel processing? Imagine painting a picket fence. Uniprocessing would be one painter painting the whole fence. With parallel processing you would assign 20 painters to the fence, each painter being an individual processor. You turn them loose simultaneously and they paint the fence in 1/20th the time. A typical PC has a single processor. Encore's systems can have up to 20 processors.

The operating system, compilers and languages keep track of everything in the computer and keep it coherently organized. But that is all transparent to the user. He solves a problem as he did in the old days. It just gets done awfully fast.

Will today's engineering workstations become tomorrow's student computers?

Whether or not that is farfetched depends on economics, although we are already headed that way. Access to very powerful computers—where you feel you have the power of the computer at your fingertips—is coming.

Ralph E. Gomory, senior vice president for science and technology, International Business Machines Corporation (IBM)

Despite the growing importance of information technology in our society, interest in computer science careers among the nation's youth has been declining in recent years. What is behind this trend?

Computers are transforming the world by what they do, not by how they work. You need to be computer literate to get your job done. But to design better computers we need only a small number of computer scientists.

Historically there have been all sorts of booms and busts in the supply of engineers. When there's a shortage everyone rushes in to become an engineer, but when they graduate there may be too many. Aside from that I don't know why there should be a shortage. It's a kind of supply and demand mechanism. All the forecasts people have made about the supply of engineers have been wildly wrong.

But that's not the thing to focus on. You have a technology that is improving 20 to 30 percent each year, and has been doing so for 20 years. It will be 10 times better in 10 years. It will be 100 times better in 20 years. That's the big event.

There's nothing else around that improves 20 to 30 percent per year. What does that mean? The word processor we have today is the kind of thing that 1,200 scientists had to share 20 years ago because it was so expensive. Now secretaries each have their own. It's not a question of whether we can train people to take advantage of this new technology; they already are.

A lot of the progress in computer science just makes computers easier to use. Look at pop-down menus and icons. A tremendous amount of computation goes into having those objects pop up or pop down on the screen. And all of that makes the computer easier to use.

How can computers make such progress? Cars don't get 25 percent cheaper every year. The key is: you don't do any work in the physical sense when you do information processing. You just deal with bits—1's and 0's. And with silicon circuitry, you make the bits a little smaller every year. And you get thousands of them embedded in just one piece of silicon.

Every year the circuits get smaller and the bits get smaller. That is an open door and we push on it a little every year. We're somewhere near the beginning now. So don't think what we have is advanced and sophisticated. It isn't. Not compared to where we'll be 10 years from now.

Andrew Grove, chief executive officer, Intel Corporation

You head a company largely responsible for making computers faster and more powerful. What is the most important impact these machines have had on our lives?

Look at what those computers are doing. They aren't doing science fiction stuff. They sit on people's desks enabling them to type faster and more accurately, to compose better, to do spreadsheets better. They do very ordinary, mundane things—faster. How many of the millions of "386s" [an advanced Intel microprocessor used in millions of powerful PCs] end up in expert systems? One-tenth of 1 percent.

Do colleges promote computers too heavily for drill and practice applications? Should students use them instead to solve conceptual problems?

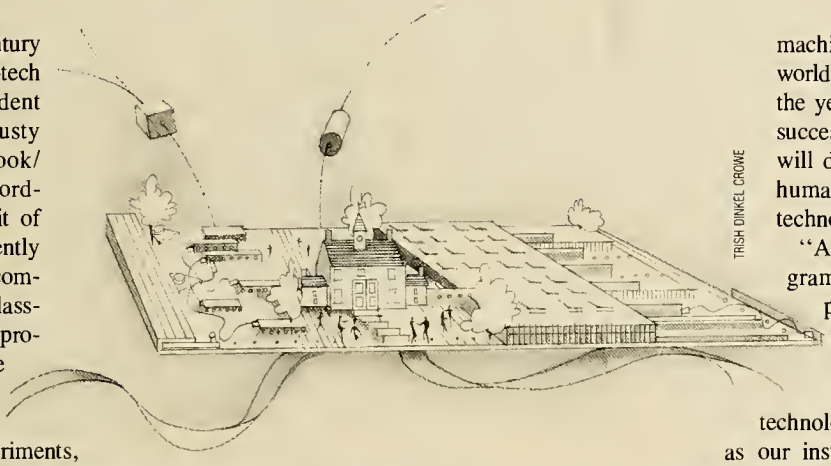
If we get too preoccupied with teaching students conceptual ideas and give them no practical skills with which to implement them, the conceptual ideas dangling by themselves will be of little use to anyone.

You can't teach students the principles of democracy without teaching them history. You can't live on concepts alone. If a person is incapable of understanding, through his own hands-on experience, what the computer can do, or is incapable of using a computer, and ends up computer-

"Electronic mail will enable students to leave questions after a lecture, and professors will be able to answer them at their leisure. If you did nothing but that, it would make the learning process more effective."

—Wil Houde

No More Teachers, No More Books . . .


TRISH DINKEL CROWE

It's the 21st century and all a high-tech college student needs is his trusty video notebook/computer, according to a portrait of the future published recently in *Business Week*. The computer provides lectures (classrooms are obsolete since professors can reach more students simultaneously with the computer), simulates laboratory experiments, and calls up information—everything from the contents of books to scenes from films or television programs—from a central library.

But there's more to predicting the future, Ralph Gomory notes, than merely predicting technology. "An electronic notebook that will hold the equivalent of many regular books and have a flat screen on which you can write, is an absolute certainty," he says. "But will classrooms be obsolete? That's where this vision and I part company.

"Yes, professors can today lecture on a computer network to students at dozens of schools. That's a fact. But will that make classrooms obsolete? I doubt it. People are people. It's not clear that they respond the same way to an image on a flat screen that they can't talk to as they do to a living, breathing human being."

"There's a theory about high tech/high touch," notes Wil Houde. "The more technical something becomes, the more contact you need with the individual using it. So even though the technology exists to automate the classroom, it's possible it won't be used because it requires a high-touch environment to succeed.

"On the other hand, professors may find that by using the new technology they have more time to work with students individually, although so much of education is exposure, which doesn't have to be one-on-one. I remember chemistry lectures at WPI on Saturday mornings. The professor made it extremely exciting and entertaining, so although it was Saturday morning, no one wanted to miss it."

"The video notebook will be possible, even economically feasible for most people, in the year 2000," says David Norton. "But will the university be able to change its structures for teaching? I think it will be a struggle. You'll have the resistance to new approaches that is always there. But ultimately an innovator will break through somewhere along the line, and that will set the pattern for others to follow. You'll have to look down the road a few years beyond the year 2000, though, before it filters into the classroom."

"The scenario may be technically feasible," Smil Ruhman says, "but it may cause the college to lose most of its social value: personal contact between students and faculty, class participation, student collaboration and competition, instructor guidance, stimulation, and role modeling. The only events still requiring student attendance would be proctored exams and any surviving laboratory experiments.

"Will the college become just a purveyor of recorded lectures and educational software, a supplier of computer and networking services, and a testing facility?"

Hans Moravec, director of the Mobile Robot Laboratory at Carnegie-Mellon University, gave the 1989 Hull Memorial Lecture at WPI. He is the author of the recently published *Mind Children: The Future of Robot and Human Intelligence*, a far-reaching look into the way intelligent machines will transform the world—and human nature—in the years ahead. He says the success of the video notebook will depend on the ability of human nature to adapt to technology.

"As humans, we're programmed to learn from the previous generation, and we have an instinct to listen to storytellers," he says. "I think these technologies will work insofar as our instincts can be perverted to match the technology, or the technology can be tailored to cater to the instincts.

"For example, using the Macintosh computer requires a different set of instincts than using conventional word-driven operating systems. You manipulate icons rather than issuing commands to, presumably, a very stupid machine.

"There's also a problem with the limited size of the screen in the video notebook. Even if you can switch around between screens really fast, you will still be able to find something on top of a table faster, or more surely, than you can by scrolling around a computer screen."

What will follow the video notebook? Moravec envisions a helmet as light as a pair of eyeglasses called a "head-mounted display." It would cover your field of vision, and with the aid of a computer, create a three-dimensional image that changes as you move your head.

"The scene will appear to stand still as you move around it, so you can create a very large work space. You'll communicate with a world network and the work space will provide high-resolution graphics and sound."

Sounds like science fiction? Moravec says something similar to the head-mounted display is already in use in leading-edge aircraft simulator technology. "It is almost possible now," he says. "You need another factor of 100 or 1,000 in miniaturization, and an increase in the power of computers, to make it work smoothly." —LG

phobic, you've lost the whole deal.

I used computers early on for specific purposes. The computer by itself wasn't a deity for me. All a computer does is reduce the time it takes to do ordinary tasks.

Do people overestimate the impact computers have had on the way we think?

Yes. And they underrate the enormous utility of computers doing very mundane stuff, and therefore improving life all over the world—just as many other inventions have done. But people didn't put those inventions on pedestals and pay homage to them.

Do you have any advice for today's engineering students?

Learn to use the computer and get comfortable with it, but don't let it seduce you. Don't become enamored of the computer and computer software by itself. If you end up being the servant of the computer, and you forget what you were educated to do, both you and society lose.

Even in the batch processing/FORTRAN days, I saw people forget physics and the fundamental problems they were trying to solve, because they enjoyed this involvement with the machine. It's a seductive machine. People immerse themselves in it for hours or days at a time. They forget to eat. They forget the fundamental purpose of their education.

Michael Gutman '58, vice president of corporate business development, Apollo Computer, Inc.

What problems stand in the way of universities taking full advantage of information technology? What can a university do to make its information system a success?

Two things are holding back students today: the accessibility and availability of machines, and the availability of easy-to-use courseware.

Why do some educational programs fail and others succeed? So many programs don't have clear goals. It's very common for our educational salespeople to run up against a situation where researchers want one thing, students—represented by the administration—want something else, the data processing center has a third set of requirements, and the administration is in yet another place. There's no central theme and no ability to communicate it.

Second, each successful program we have seen has been served by an ongoing "operating committee" composed of students, data processing center personnel, administrators, and research and teaching faculty.

Third, funding for success is the beginning of the information technology "food chain." Most programs come unglued here. A comprehensive plan that utilizes all sources of funding—funds from industry, government and academic consortia, research grants and student fees—needs to be drawn up.

Fourth, individuals and departments must take ownership for their pieces of the system. Colleges and universities should be sure the hardware and software they select is equal to the task at hand, and they should keep the variety of equipment to a minimum. It takes courage to turn down a donation of equipment, but if it doesn't fit the task or is too old or is obsolete, it will drain away precious resources. Be sure also that you have planned adequately for service for the equipment. Industry hates to see donated or purchased equipment used improperly by faculty and students.

Fifth, make sure that everyone within the college or university community has reasonable access to the system. Too many systems address only the needs of research faculty and graduate students, placing undergraduates and teaching faculty far too low on the access list.

Sixth, create a clear focus on the development of courseware. Look at what others are doing, create courseware consortia with other colleges and universities, and extend the university "reward system" beyond research to include courseware development.

Seventh, and of equal importance to the other points, educate everyone in the use and benefits of the information technology system. This needs to begin at the top of the university and include all facets of the administration, not just the data processing staff.

These points may not constitute the only road to a successful university computer environment, but I haven't seen a successful one yet that ignored either the mystical or the mundane.

Wilfrid Houde '59, president and chief executive officer, Seehorn Technologies, Inc.

How do computers change the way teachers teach?

Using computers, you have so many more "what-ifs" and variables that you can plug into an equation. You can get a better feeling for what's going on and plot it visually. When I went to school, you had to use a slide rule and draw your results on graph paper; you could complete only one or two curves. Now you can look at all kinds of extremes.

The classroom hasn't really changed since the early days of Rome. It's a very inefficient system for the transfer of information. WPI has done it right by making sure everyone is hooked together on a high-speed data network. On a campus, electronic mail will enable students to leave questions after a lecture for their professors. And professors will be able to answer them at their leisure. If you did nothing but that, it would make the learning process more effective.

What about professors who don't want to follow that route?

Hey, what did you do with the brakeman on the railroad? That's what's going to happen. It'll pass them by.

"Day in and day out, I see companies that have new world technology and old world organization approaches. . . . But until you change that basic structure—the chain of command—nothing's going to change. That's the real issue. It's not technology." —David Norton

Who's Who: An Expert Data Base

Wil Houde specializes in office automation, quality improvement and customer satisfaction. His most recent venture, Seehorn Technologies, builds a desktop publishing product that allows a user to edit videotape on a Macintosh computer. After graduating from WPI, he received an M.B.A. from Wharton and did graduate work at MIT. He worked for AT&T, Hewlett-Packard and Apple Computer before, in 1983, founding ViMart Corp., a maker of interactive laser disk systems for personal computers. He is a member of WPI's Board of Trustees and chairman of its Electrical Engineering Advisory Committee.

Ken Fisher founded Encore Computer Corporation, which makes computers that have an innovative new architecture, in 1983. Between 1970 and 1975, Fisher was vice president of central operations for Honeywell Information Systems. He joined Prime Computer, Inc. in 1975 as president, chief executive officer and director. In six years, he increased company sales from $7 million to $365 million. He holds a bachelor's degree from the University of Nebraska and an M.B.A. from the University of Chicago. Encore recently acquired Gould/Computer Systems Inc.

David Norton's firm, part of Peat Marwick Main and Company, is a multinational professional company specializing in the management of information technology. It has a staff of 150 and offices in nine cities in the U.S. and Europe. He holds a bachelor's degree in electrical engineering from WPI, a master's in management from Florida State University and a doctorate in business administration from the Harvard Business School. In addition to consulting for many Fortune 500 companies, he has directed major research projects for Nolan, Norton & Co..

Ward MacKenzie graduated from WPI in 1961 and received an M.B.A. from the Amos Tuck School of Business at Dartmouth. He worked for Digital Equipment Corporation for 18 years, most recently as vice president, volume group. Between 1985 and 1987 he served as chief executive officer and chairman of Lisp Machines, Inc., an artificial intelligence company. He joined Data General Corporation in 1987, where he was responsible for the company's worldwide marketing activities. He left Data General this year to form his own consulting firm.

Smil Ruhman earned a B.S. from WPI and an M.S. from the University of Pennsylvania's Moore School of Electrical Engineering. In the early 1950s, he helped develop plans for the first stored-program computer. In 1957 he formed Packard Bell Computer Corp., which developed the first transistorized analog-to-digital converter, a digital analyzer for the space program, and the Packard Bell 250, the first minicomputer. In 1963, Ruhman joined the Weizmann Institute, where he has developed two generations of scientific computers.

Ralph Gomory went to work for IBM in 1959 as a research mathematician and rose steadily through the company's ranks. He was named an IBM Fellow, a rank conferred on only a small number of the company's distinguished scientists and engineers, in 1964. In 1970 he became director of research, and in 1986 he assumed his current position, in which he is responsible for IBM's research activities, science and technology assessment, and university relations. The author of more than 50 technical papers, he received the National Medal of Science in 1988. He is a trustee at Princeton University and has been an Alfred White Professor-at-Large at Cornell University.

Jack Shields started at DEC in 1961 as a field service engineer and rose steadily through the ranks, becoming vice president for field service and training in 1974, vice president of customer service in 1979, and vice president and group manager of sales, service, marketing and international in 1981. He was appointed to his present post in 1986. A graduate of the WPI School of Industrial Management and the Harvard Graduate School of Business Administration's Program for Management Development, he is a member of the board of trustees at Clark University and a member of Digital's Executive Committee.

In 1968, **Andrew Grove,** a native of Hungary, participated in the founding of Intel Corporation, inventor and manufacturer of microprocessors, memory chips and other microelectronics devices that have literally changed the face of modern computing. Grove was named president of Intel in 1979 and chief executive officer in 1987. He received a bachelor's degree in chemical engineering from the City College of New York and a Ph.D. from the University of California, Berkeley, where he taught a graduate course in semiconductor physics. He is the author of more than 40 technical papers and several books.

Mike Gutman received bachelor's and master's degrees in electrical engineering from WPI. He has held engineering, marketing and sales positions with a number of high technology firms, including MITRE Corporation, Digital Equipment Corporation, Apollo Computer, Inc. and his own company, Digital Marketing Associates, Inc. Apollo created the workstation industry in 1980 with its network-based, high-performance graphical workstations. Apollo was recently acquired by Hewlett-Packard Company, creating the world's largest supplier of workstations.

Ward MacKenzie '61, independent computer consultant

College instructors often point to a lack of courseware, software written to help professors teach, as an impediment to greater use of the computer in education. Why isn't more courseware being written?

The assumption has always been that people in the schools would design their own courseware, since there really isn't enough of a market for the computer industry. The leadership really has to come from the faculty.

I had a different experience with courseware when I attended the Amos Tuck business graduate school at Dartmouth. I was there in the mid-1960s, when they first put a time-sharing system on campus. The professors tightly integrated the use of computers into the curriculum in management, economics, accounting, business planning and mathematics. It became almost overwhelming.

What is the best way to incorporate the computer into education?

Students become excited about computing through their curriculum, by using the computer to solve problems. If they do projects by using computer techniques, it's something they will never forget. That is how they will take advantage of computers when they get into the work world.

David Norton '62, president, Nolan, Norton & Co.

Is the management of information technology a concern at colleges?

There's this tremendous underlying promise in the corporate world that everyone believes deep down inside: that the computer and information technology are revolutionizing the world around us. For the past decade, 50 percent of the investment capital in the United States has gone into computers and information equipment, which implies a de facto commitment by the private sector. There's no national program, just thousands of individual decisions with the expectation of a payoff. Yet economists see a drop in productivity among "knowledge workers" in the U.S.

Day in and day out, I see companies that have New World technology and Old World organization approaches—management structures put in place 50, 60 or 70 years ago; big manufacturers that have 14 layers from top to bottom. An engineer typically has a problem communicating with someone in the manufacturing division. So now you bring in a phone mail network that allows engineering and manufacturing people to communicate. But until you change that basic structure—the chain of command—nothing's going to change. That's the real issue. It's not technology.

At universities, as in other organizations, we build structures that people have a vested interest in preserving, and that makes it very difficult to change.

There's another wave coming of people who grew up comfortable with screens and mice and joysticks. There's not going to be a mandate one day that says, "We will not respect the chain of command. We will network." It will just happen.

Young people come out of college today knowing how to network with people tied into bulletin boards all around the country. The fact that they may be in an organization in New York with a hierarchy and five levels of organization won't stop them from networking with people with common interests anywhere in world.

Smil Ruhman '49, the Norman D. Cohen Professor of Computer Science, Weizmann Institute of Science, Israel

How should information technology be integrated into the educational environment?

There are a number of high-tech educational tools already available that we should look at. Computers allow us to simulate experiments that would otherwise prove too costly, too dangerous or simply impossible. Through simulation, we can integrate complex functions on a chip, perform life-threatening chemical experiments, or study the global effects of economic measures.

In addition, the computer has proved its ability to teach by programmed drills and exercises. Yet computer instruction tends to be isolating and impersonal for some people. One alternative medium is the live video broadcast, particularly the video conference, which allows questions from the "tele-audience" to be answered during the broadcast. In the future, libraries of such videotapes and educational films could become available to the student on his portable, high-resolution display over a high-bandwidth, glass-fiber network.

I don't hesitate to recommend the full application of high technology to evening school, extension school and non-research, advanced degree studies. This will minimize attendance requirements, and make higher education available to people too busy to attend day and evening classes.

In harnessing computer and information science to higher education, the major problems will not come from hardware or technology, but in preparing, debugging and updating the courseware. Even such a relatively stable field as ancient history is affected by archaeological finds. The discovery of the Dead Sea Scrolls or the ancient Elba (Syria) Tablet Library, for instance, required drastic revisions in the history curriculum.

John J. Shields '69 SIM, senior vice president, sales, services, and international, Digital Equipment Corporation (DEC)

What are the most important impediments to the full utilization of information technology in higher education?

People really haven't yet developed the tools to enable the efficient development of courseware. It's a little like programming was 25 years ago—very, very difficult. People have since developed higher-level languages, compilers and computer-based tools that enable software engineers to write software much more efficiently. As similar tools are developed for courseware, we'll see a much broader utilization of the technology. DEC is working with MIT on a project that uses interactive video for computer-aided instruction. We're running it on VAX workstations.

The MIT researchers have developed about 15 different courses, including aeronautics, thermodynamics, architecture, electrical engineering and some humanities courses. It allows the instructor to build a course using video disks synchronized with text, graphics and video frames. One course—an aeronautics sequence—lets you simulate the performance of an airfoil in a wind tunnel. The student can modify the airfoil and see the results on the screen.

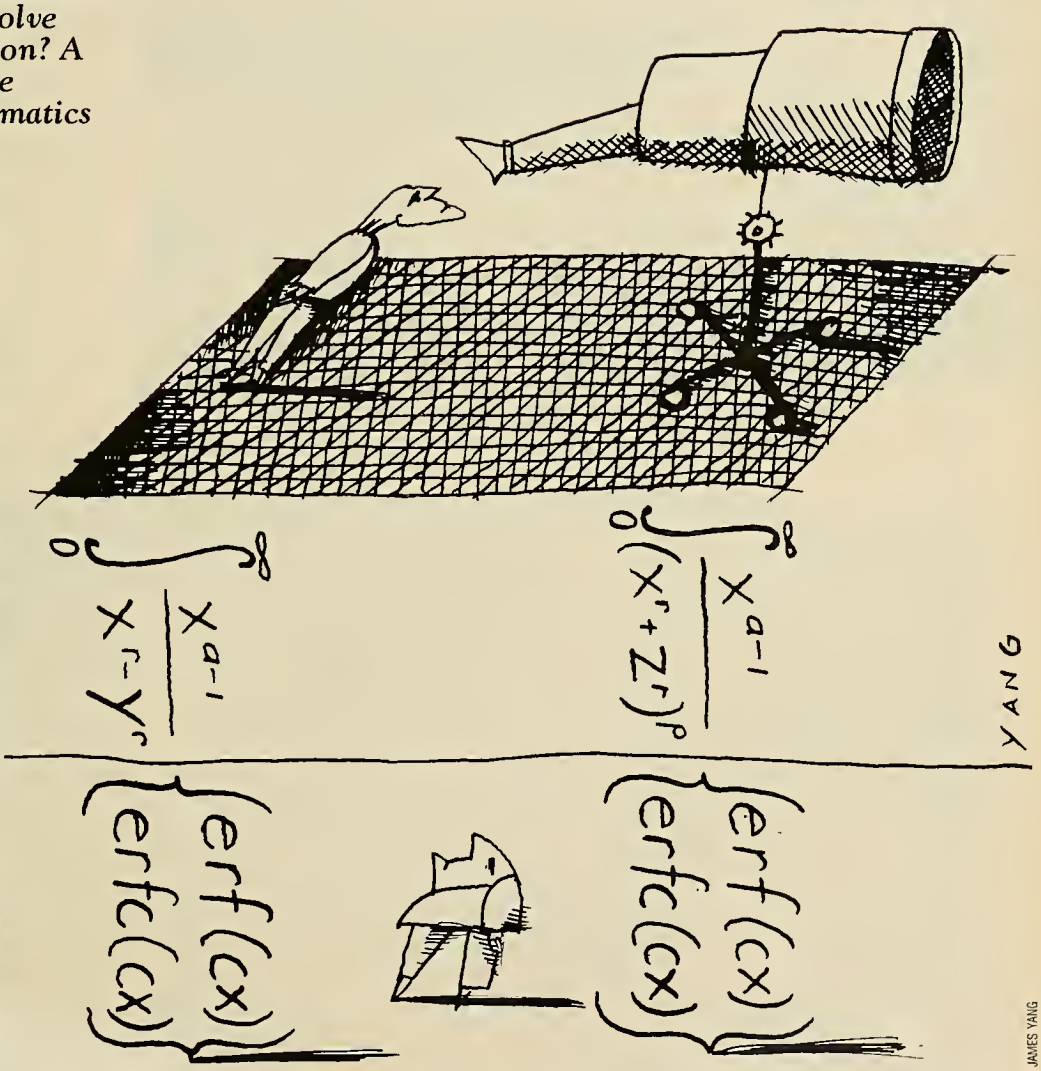
You can let someone mix a chemical experiment at a workstation. If they do anything dangerous, you can "blow up" the experiment on the tube. Instead of showing students a simulation of flying, imagine calling up an actual video of the landing of an aircraft. It gives you a sense and feel that you're actually there.

In another area, optical disks can now store massive amounts of information. With this archival capability, you could store your entire library on disk. If you're connected through a network to the other schools in your area, a student could sit at his desk and have access to many libraries.

Goodwin is a freelance writer from Worcester who writes frequently on business and finance.

CALCULATED RISK

WPI's calculus courses weren't teaching students how to use this fundamental tool to analyze and solve problems. The solution? A major overhaul of the college's basic mathematics curriculum.
By Amy Zuckerman



The study of mathematics is apt to commence in disappointment.... We are told that by its aid the stars are weighed and the billions of molecules in a drop of water are counted. Yet, like the ghost of Hamlet's father, this great science eludes the efforts of our mental weapons to grasp it.

—Alfred North Whitehead

Last February, William J. Hardell, professor of mathematical sciences, and the WPI Basic Mathematics Courses Revision Committee issued a major salvo to the college's faculty.

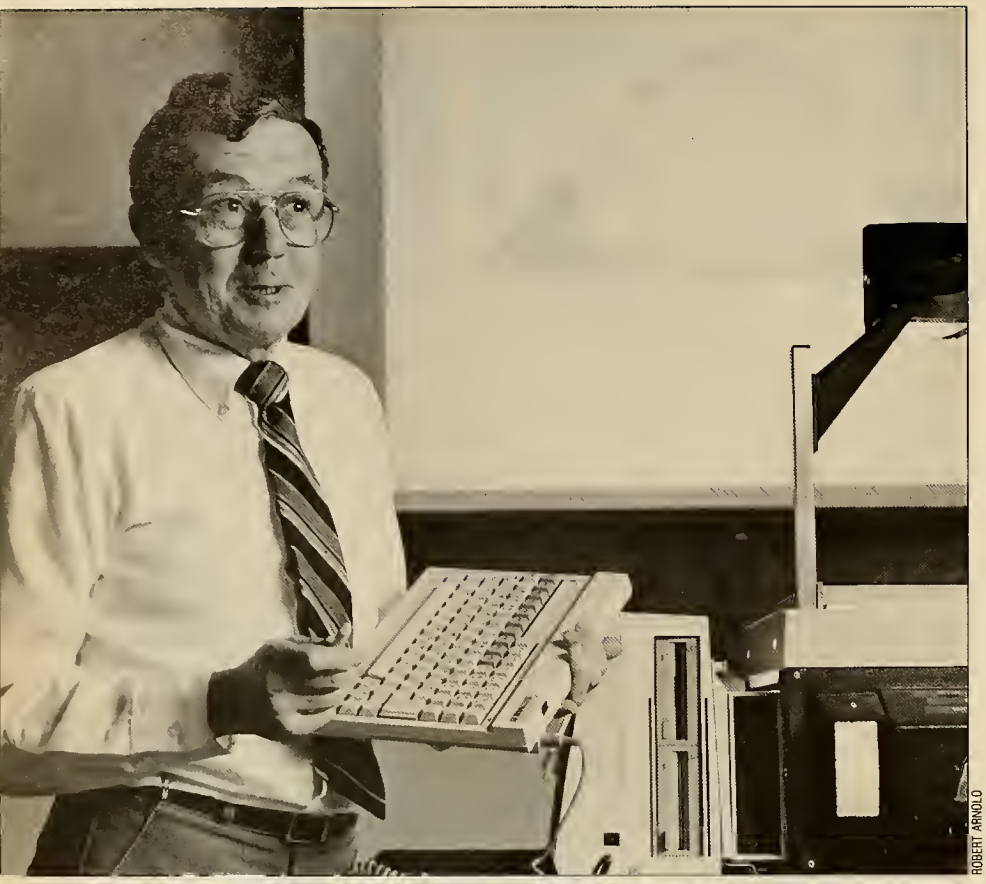
The manner in which calculus was being taught at WPI, they said, was verging on obsolete. WPI's calculus courses were teaching students to manipulate formulas, rather than to analyze and solve problems.

Like others who favor a change in calculus instruction, the committee recommended leaving the sheer manipulation of calculus to calculators and computers, which are faster and more accurate than humans. While students need to learn techniques, they should also master the concepts of calculus, they said.

Problems in calculus instruction are not unique to WPI; they can be found at colleges across the country. Pointing to nationwide studies, Hardell says, "students are not able to effectively use calculus in solving problems in other courses, and what a student learns has little relevance in the workplace.

"Some have gone as far as to say that calculus is not as important as it once was, that discrete mathematics is at least as valuable."

As a result of the memo and the research that predated it—an effort launched by Samuel M. Rankin III, head of the Mathematical Sciences Department, and pursued by Hardell and Mathematics Profes-



ROBERT ARNOLD

In a new approach to teaching calculus at WPI, shaped in part by William J. Hardell, computers do the routine math and help students visualize concepts.

sor J.J. Malone—a pilot calculus program was designed and implemented for the first time in the fall of 1988.

The pilot program accomplished two important goals of the Basic Mathematics Courses Revision Committee. It integrated computers into calculus instruction for the first time at WPI, and it set in motion a revision of the college's traditional calculus sequence.

Hardell and Malone say the pilot program has been a success, though they also admit it still requires some fine tuning. Nevertheless, believing the need for reform of the traditional calculus sequence is urgent, they recommended that the pilot program be adopted as the standard math sequence for all freshmen attending WPI.

Not everyone in the mathematics department agreed initially, they note, and the proposal did not immediately win the approval of the entire faculty, but in the end the recommendation carried the day. As a result, beginning in the fall of 1989, incoming freshmen will find computers in their calculus classrooms; an emphasis on concepts, not techniques, in their classroom work; concentration on real-world problem solving; and a glimpse of how calculus is applied to other fields.

Why all this tumult about calculus, one of the most basic (and oldest) facets of modern mathematics?

There has been growing concern in the American mathematical community in recent years over the manner in which students are introduced to calculus. Malone points out that, nationwide, the student failure rate in calculus is 30 to 50 percent.

"The problem is that calculus courses have, more and more, come to concentrate on the techniques of differentiation and integration," Malone says, "rather than exploring the concepts of calculus and its applications. As a result, students have become lost in the forest, seeing only the trees."

In support of this view, Malone and Hardell point to two major reports on calculus education: *Toward a Lean and Lively Calculus,* which came out of a Tulane University conference on mathematics sponsored by the Sloan Foundation; and *Calculus for a New Century,* the outgrowth of a colloquium conducted in October 1987 by the National Research Council. This was just part of the council's ongoing project, *Mathematical Sciences in the Year 2000.*

"There was a feeling that educators had created a calculus treadmill," adds Malone. "Students didn't seem to be absorbing what they'd been taught. Even the upperclassmen seemed baffled by calculus."

Impetus for change also came from WPI faculty members who teach in engineering and science disciplines that require students to have a grounding in calculus. Malone and Hardell, along with others in the Mathematical Sciences Department, fielded many a complaint that students were unprepared for coursework in their major fields.

"The major problem as I see it is that the students don't appreciate the physical implications of the mathematics," notes John M. Boyd, professor of mechanical engineering. "They do operational manipulations, but are not particularly interested in understanding the physical descriptions of those operations."

This lack of understanding becomes especially apparent when real-world problems come into play. "It's hard to carry on an intelligent conversation about the gross national product without understanding the concept of a derivative," Boyd offers as an example. "They can take derivatives of functions, but have no appreciation of the importance of derivatives in the physical world in all sorts of applications—from economics to stress analysis."

Peter Levin, assistant professor of electrical engineering, also wants to see more time spent on fundamental skills. He says he feels his colleagues have to spend too much time "rattling loose poorly laid mathematics groundwork."

Hartley Grandin, professor of mechanical engineering, finds that students often forget much of the calculus they learned by the time they get to his classes. "The mathematics sequence comes too early in their careers. It might be better if they had it later so they could, for example, combine differential equations with the study of vibrations. That might be a better fit."

Malone, Hardell and the Mathematical Sciences Department faculty have worked hard to address these concerns. If they could do little to improve students' study habits and ability to absorb and retain material, they decided they could at least do something about the material being absorbed. The fact that existing calculus texts emphasize techniques at the expense of concepts made the job more challenging, as did WPI's seven-week term system.

But neither Malone nor Hardell was de-

terred. One thing working in their favor was a department head who believed in their mission. Although there had been discussion of changing the calculus sequence prior to Rankin's arrival in the summer of 1987—Malone and Hardell agree that "things had been stewing for some time"—Rankin was the needed catalyst for change.

Financial assistance arrived in November 1987 in the form of a $5,000 grant from the WPI Educational Development Council. Hardell and Malone have used these monies and a matching grant from the Institute's course development funds to work on a revision of the calculus sequence.

In the course of their ensuing research, both professors adopted the philosophy of the "lean and lively calculus." By lean, Malone explains, mathematicians mean eliminating "some calculus topics to make way for emphasis on analysis and concepts. In the future you may see elimination of some of the techniques of integration, for example."

The lively part, he adds, "is the emphasis on making calculus relevant." Both Malone and Hardell laugh at the "real-world" examples they see in many of today's textbooks. "It's always a field against a river," says Hardell, referring to area problems. "That's what passes for an application in many calculus texts."

The debate at WPI is being echoed on campuses nationwide. Last October, Hardell attended a meeting on calculus reform at which the revision efforts of a major midwestern university were mentioned. He was struck by the fact that after two years the members of the university's calculus reform committee still could not agree on which topics to eliminate, if any.

Despite the confusion, there is no doubt in Hardell's mind that the "lean and lively" approach is fast becoming the dominant one. The new direction is evident in a recent list of National Science Foundation grants, with funds going to schools as diverse as Smith College, the University of New Mexico and Purdue University for the study of calculus revisions.

With these issues in mind, Hardell, Malone and the Basic Mathematics Courses Revision Committee adopted the following goals:

- Change the orientation of calculus from an emphasis on techniques to an emphasis on understanding concepts.
- When structuring courses, be cognizant of the skills students will need in later coursework in their major fields and in the workplace.
- Develop applications that help students understand the uses of calculus and foster a problem-solving approach that leads students to question and think.
- Integrate the use of computers into the sequence for use by instructors and students.

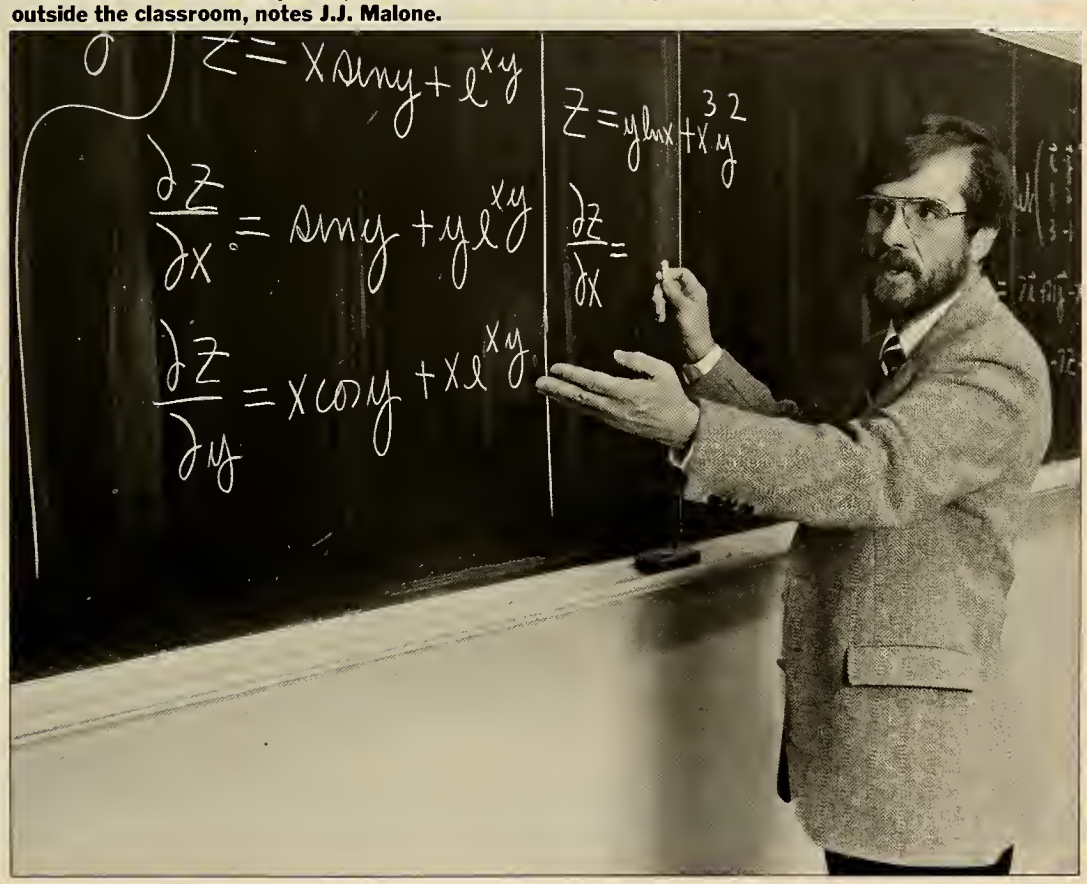
Some in the Mathematical Sciences Department did not immediately see the need for these changes. "Initially, there was very little agreement," concedes Malone. "We had to spend a lot of time convincing people that this was the right direction."

"It wasn't so much criticism of the new approach," explains Hardell. "It's just that there are certain things people can't conceive of eliminating: powers of trig functions, for example, techniques of integration or partial fractions. We're sure if we eliminate them there will be screams of anguish from someone."

When it came to actually designing a pilot curriculum, Malone and Hardell argued in favor of interweaving differential equations throughout the sequence instead of making this area a separate course of study. The idea was to break down barriers between topics, to integrate them in order to reinforce basic concepts. Also, both favored more emphasis on numerical integration, which they said had been all but ignored in traditional calculus sequences.

The computer also played an important role in the new program. By freeing them from the time constraints of number crunching, the computer enables instructors to concentrate on concepts and introduce students to topics that were previously inaccessible by virtue of the complex arithmetic that accompanied them. And, it paves the way for integrating real-life calculus applications into the curriculum.

In WPI's new calculus sequence, students work at real-world problems to see how they'll use calculus outside the classroom, notes J.J. Malone.



ROBERT ARNOLD

In the fall of 1988, freshmen were given the option of studying calculus in the traditional fashion or entering the calculus pilot program. Enough students chose the pilot to comprise three of the nine calculus sessions. By the time the pilot program ended in early March, about a third of the volunteers had returned to traditional calculus study.

Because of time constraints and the need to fine tune, the course topics were similar to those taught in the traditional sequence. The primary differences, according to Malone and Hardell, were an emphasis on the presentation of a wide range of topics and the extensive use of the computer. Software was placed in the main computer lab for use outside the classroom and many assignments were designed for the computer.

One important change was made to the original plan. Out of deference to the wishes of several faculty members, differential equations will continue to be taught as a separate course rather than being woven throughout the study of calculus.

"Some who teach differential equations," Malone explains, "want to continue teaching this as a separate course. And, from the viewpoint of engineering accreditation, it may be just as well to have a separate differential equations course."

Student evaluations of the new calculus sequence were mixed. Most concluded that the pilot was more demanding than the traditional course work, but most also found the new approach more interesting and challenging than what their peers seemed to be studying (the only basis most had for comparison).

"We succeeded enough for the model to be adopted for all freshman calculus classes next year," Hardell explains. "It will be an outgrowth of this year's efforts, but with some modifications."

The efforts to improve the new calculus sequence continue. Members of the Mathematical Sciences Department plan to approach other departments, including mechanical, civil, electrical and chemical engineering, to gain insight into how calculus is used in these fields. This understanding will be passed on to students, both to bring real-world problems into the classroom and to expose students to issues they will face as engineers.

Both professors see new problems on the horizon as they continue to implement the new sequence. For one, they argue that the students will need access to additional computers. If new computer labs can't be created or present labs expanded, they say, it may be necessary for all students to own their own computers.

Currently, the Mathematical Sciences Department is awaiting word on a proposal to the National Science Foundation for a grant of more than $92,000 to establish a computer lab dedicated to undergraduate education. Under the direction of James L. Northrup, assistant professor of mathematics, the NSF monies would be used to equip the lab with 18 high-resolution graphics workstations. By providing students with state-of-the-art computation equipment, Northrup says he hopes to teach students to use computers as part of their normal approach to solving technological problems.

"By starting out with computers of sufficient power," Northrup wrote in his NSF proposal, "we expect to be able to use the same machines during the entire mathematics curriculum." The machines would also be available for use in student project work, he notes.

On a second front, Malone and Hardell foresee the need to teach calculus over five terms, rather than the traditional four. More likely than not, an extended calculus schedule would mean the elimination of one elective course from a student's schedule. Although they feel the gain (a better grasp of calculus) would outweigh the loss of one course, the professors also recognize that other faculty members—particularly those in other departments—may disagree.

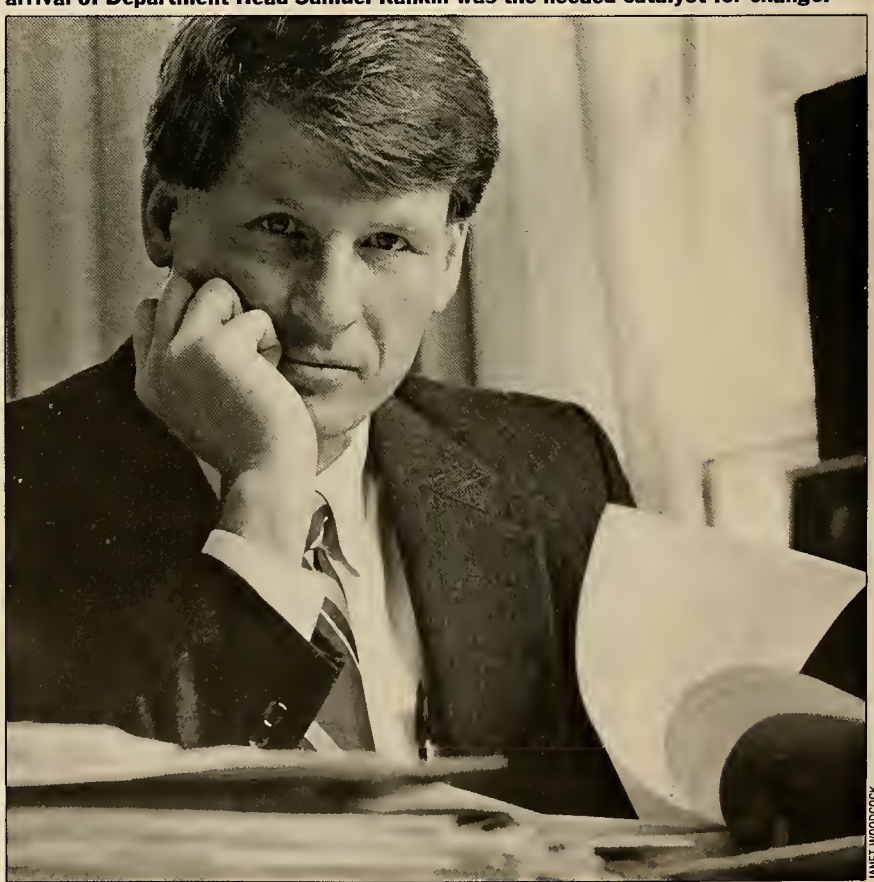
"We're pleased with the way we've been able to introduce the computer into calculus, but there's still work to be done," says Malone. "We'd still like to implement a more radical change in the mix of topics, but that's not going to happen immediately, since calculus texts which take the 'lean and lively' approach have yet to be published."

Still, both men take satisfaction in the changes that have been wrought this year. They knew success was on the horizon when a student indignantly demanded to know what they were doing. "This isn't anything like our course in high school," he complained.

That was precisely what Hardell and Malone had in mind.

Zuckerman, a freelance writer from Shrewsbury, Mass., is a frequent contributor to the Journal.

While ideas for a new calculus sequence had been "stewing" for some time, the arrival of Department Head Samuel Rankin was the needed catalyst for change.



JANET WOODCOCK

EQUAL TO THE TASK

Teachers plug some fun into the fundamentals to help solve America's math education crisis.
By Lisa Hooker

JAMES YANG

Jahn Buhrman sometimes asks this question on a high-school geometry test: "If you were an acute angle serving on a committee with three obtuse angles, how would you feel?"

She likes it because it has many right answers—and none of them involve symbols or equations. Sure, she says, to answer the question her students have to recall that acute angles are less than 90 degrees, while obtuse angles are greater than 90 degrees.

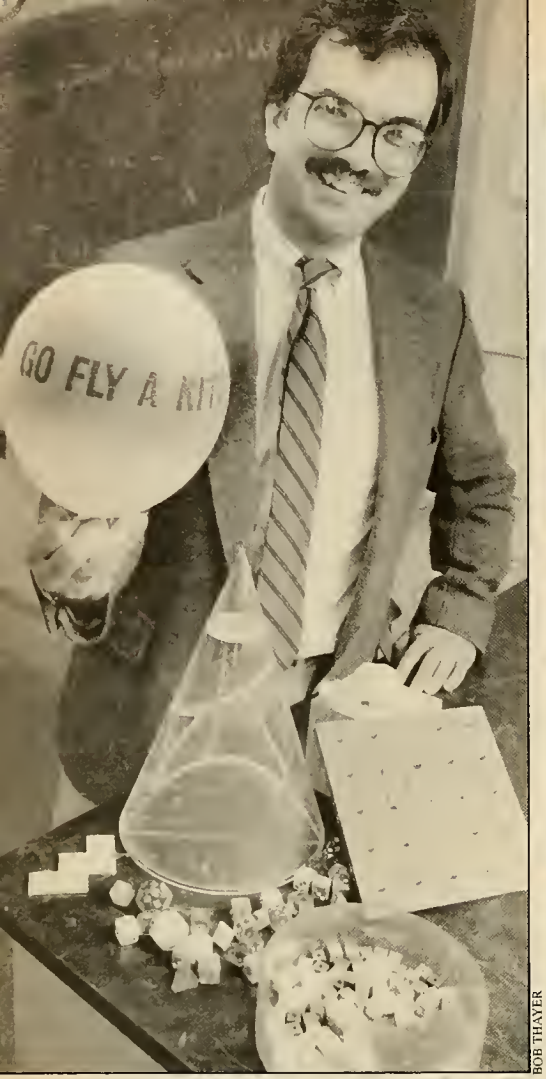
But the responses often are humorous, creative, and thoughtful: "I'd feel very funny." "I know I'd have three strikes against me." "I'd be the oddball in the group." One enterprising student wrote: "If I were an acute angle of 60 degrees, I'd ask if I could bring another 60-degree member into the committee, and together we would make more than 90 degrees."

Her students quickly realize that this is not just another math course. On her tests, essay questions are as common as equations. She wants her students to think, rather than just memorize. She also wants them to have fun.

Having fun was far from Frances Caporello's mind when she first faced a class of Cambodian refugees. She was charged with teaching basic high-school math to a room full of teenagers, some as old as 19. They spoke no English. She spoke no Khmer.

She did a lot of drawing and gesturing. They did a lot of discussing among themselves. When they came to a conclusion about how to solve a problem, they consulted Caporello. More gesturing and drawing took place. Slowly, they learned.

"It was really a tough job," she recalls. "But those kids worked hard to overcome



BOB THAYER

Loring Coes plots a few surprises to make algebra a lively subject.

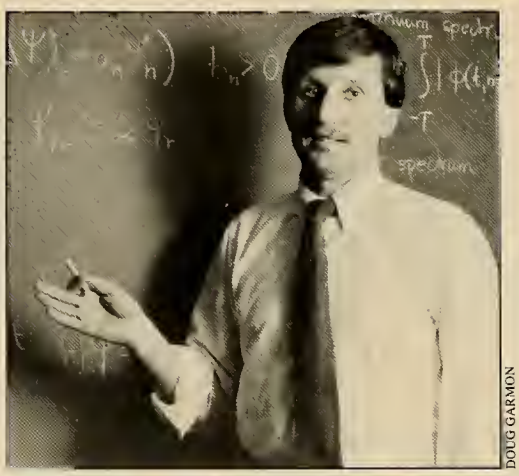
any obstacle. And I learned something important: American kids don't have enough motivation to learn math."

Her experience reinforced her belief in hard work as a key to math success. But she also thinks a teacher has to show the way. "I let kids know what math is—and it isn't two plus two," she says. "That's counting. I tell them how much I like math, even if they don't. And I tell them it's okay for them not to *like* math. But it's *not* okay for them not to *do* math."

Loring Coes III greeted his algebra students with a pack of balloons.

They were studying functions. But instead of having them scribble equations in a notebook, Coes told his students to spend the period blowing air into the balloons and dropping them to the floor. They kept track of how many breaths they used and how many seconds each balloon stayed aloft.

The result was an analysis of the flight time of balloons as a function of the number of breaths used to blow them up.



DOUG GARMON

Students enter college poorly prepared for even basic math, says Wojbor Woyczynski.

"I'm an experimenter," says Coes. "I try to get away from the idea of me lecturing all of the time. I want them to see math as more than notes on a piece of paper. I try to show them why math is valuable."

They teach in different states. Their classrooms often have little in common except math. Almost every student that Coes encounters at Rocky Hill School in Warwick, Rhode Island, is college-bound. In Maryland's Carroll County, Buhrman, who is the assistant principal at Francis Scott Key High School and a former math teacher, has seen her share of remedial students. In Massachusetts these days, Caporello has an easier time talking to her English-speaking students at Amherst High School. But she still wonders how well she is communicating in math, a language that seems so foreign to her American charges.

What these teachers share is a reputation for excellence in math education. They are committed to creating a classroom environment where children can succeed.

At a time when federal agencies seem to be churning out reports criticizing pre-college math education, good math teachers are in demand. Too many students are leaving the nation's high schools unprepared for either college or careers, the reports say.

One study found that only 7 percent of American 17-year-olds planning to attend college were adequately prepared in math. Another stated that three out of four students today stop studying math before acquiring the skills necessary to work in industry. When many high-school graduates can hardly even balance a checkbook, what part can they play in checking the decline in the nation's balance of trade? Businesses often end up footing the bill for the failings of schools: They spend about $40 billion a year on remedial tutoring for employees, or more money than is spent on elementary and secondary math education combined.

Last fall, 121 freshmen at Case Western Reserve University (CWRU) who were enrolled in a calculus course failed. This represents about one-third of the class—an extraordinarily high figure for the university.

At Worcester Polytechnic Institute (WPI), a dozen freshmen were offered a special calculus course reserved for math majors. The students all boasted strong high-school backgrounds in math. But according to the professor who taught the course, only two of the 12 were able to apply calculus concepts rigorously.

"Students are coming to us unprepared to do basic college math," says Wojbor Woyczynski, who chairs CWRU's math department. "They arrive weak in the basics: algebra, geometry, and trigonometry."

The problem is hardly limited to those schools. How could college students, many of whom scored exceptionally well on one of the tests used to admit them—the math portion of the Scholastic Aptitude Test (SAT)—be so ill-prepared in math?

"What has happened in the last few years is this: There was pressure on high schools to improve math education. There was pressure to do something. But there was no coordinated national plan for how to go about this," Woyczynski says.

"One answer for many high schools was to teach math based on the SAT. So while we haven't seen a decline in the test scores, we have seen poorer preparation.

"A number of high schools decided the best way to prepare students was to give them more math—to give them calculus. But a lot of schools were not prepared to offer calculus. And this did more harm than good," Woyczynski adds.

"High-school calculus is not taught the way we like," agrees Samuel Rankin III, head of the mathematical sciences department at WPI. "In high school, kids are praised for mundane calculations. They're not asked to do higher order thinking. They never make their brain hurt. One study showed that kids won't work on a math problem for more than three minutes."

This semester at CWRU, many of the students are retaking calculus and getting help from tutoring services on campus. Stunned by the failure rate last semester, math professors have made a point of calling struggling students one by one to suggest the service. The faculty is currently revising the content of the course, and changes in the curriculum are anticipated.

The problems in math education didn't start in high school, and they didn't happen overnight. Studies show that students in grade school are already falling behind. A recent international comparison of math and science skills, undertaken by the National Science Foundation (NSF), showed American 13-year-olds scoring near the bottom—worse or no better than their peers in Canada, Europe, and Asia.

"We are boring and scaring our kids to death with math, and it doesn't have to be that way," says Francis "Skip" Fennell, chair of the education department at Western Maryland College (WMC). As a math teacher for 22 years, Fennell has strong feelings about how math is—and should be—presented to children. And as lead author of one of the major math textbook series in use today, he challenges math teachers to do a better job.

"When teachers teach, they need a curriculum. In math classrooms, that tends to be a textbook. So we need to be careful about what we provide teachers," he emphasizes.

California's board of education rejected nearly 150 math texts and student workbooks before accepting Fennell's series, which integrates math concepts with skills and connects math to daily life. Today 40 percent of California's schools use his series, called *Mathematics Unlimited*.

Fennell believes elementary school teachers too often emphasize computation—addition, subtraction, multiplication, and division—at the expense of such topics as probability, statistics, and geometry. Traditionally, most students don't encounter those subjects until high school, if then.

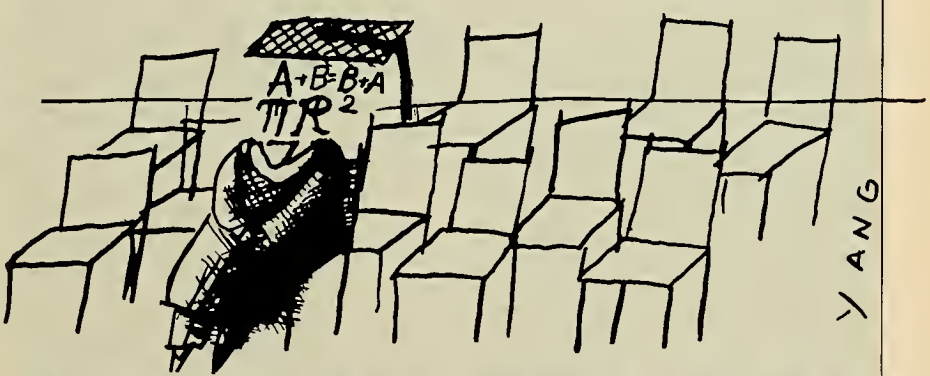
"It's been my experience that kids start out liking math. But then we make them do the same thing again and again, all through elementary school, until their minds are numb. Then, boom, in high school we hit them with algebra and geometry. They've never seen those topics before, so we blow kids away. And then we lose them."

Elementary schools do a good job teaching how to solve equations, he said, but not *when* to add, subtract, multiply, or divide. Nor do schools teach children number sense—for example, how and when to estimate.

At the high-school level, the problems often are caused by an outdated teaching style stressing lectures and seat work. Students need to interact with one another and with the teacher, to work with real-life examples, and to learn that math is a changing discipline that they can even question, he says.

A LOSING NUMBERS GAME

Too few Americans are becoming mathematicians.



Fifteen years ago, 1,000 math PhDs graduated from U.S. institutions, and 75 percent of them were U.S. citizens. Last year, 804 PhDs in mathematics graduated from U.S. institutions. Of these only 45 percent were U.S. citizens.

While this gives those graduates a wonderfully competitive hiring environment, it makes it tough for universities and businesses to find enough qualified mathematicians. Thus the future of mathematics as a profession is of great concern to many, including Samuel Rankin III, professor of mathematics and department head at Worcester Polytechnic Institute (WPI).

Business and industry are becoming concerned that their employees in entry-level positions have little or no mathematical skills. With the nation's increasing dependence on technology, this lack of skills becomes a growing and costly problem to remedy. Businesses depend upon mathematical expertise for decision-making, scheduling, resource allocation, strategic planning, and investment strategies, among other areas.

Demographics offer another challenge for math education. Traditionally, college math departments have targeted white males for their programs. But by the year 2000, only 33 percent of the incoming college-age population will be white males. Colleges and universities must address such demographics. To ignore women and minorities "is to say that you don't have a national conscience. Poorly prepared people will affect us all," he believes.

Rankin is proud that more than 40 percent of WPI's math majors are women, including its two most talented math majors this year. "Both women are aggressive and have done interesting things," he notes. And both are reportedly getting top-flight job offers.

—Amy Zuckerman

JAMES YANG

PETER HOWARD

Jahn Buhrman insists her geometry students have a piece of the action, and enlists a pizza to prove the point.

Buhrman, who earned her bachelor's degree from WMC in 1965, agrees that math teachers must help students "own the learning process," or understand not only what they are doing, but why they do it.

Her geometry students, for example, spend hours cutting and pasting shapes. "That sounds really funny in a high-school situation, but I really believe kids need to use rulers, need to use compasses, need to learn to measure."

Buhrman was the second of three WMC graduates in the past three years to receive the highest honor a pre-college math teacher can merit: an NSF Presidential Award for Excellence in Mathematics. The secrets of her success are simple, yet all too rarely found in other classrooms. She listens to students. She has them write a lot about math. She fills her lectures with practical examples. And she forces her students to be active in every aspect of their education, from designing their class projects to suggesting their own exam questions.

Students are often paralyzed by their fear of math, she says. To give them confidence, and to help her determine where they are having difficulties, she insists students talk about their problems.

"I say tell me in writing why you think you got this problem wrong. Why did you find it so difficult?

"When a student comes to me and says, 'I just can't do this,' I say, 'Okay, what can't you do? Can you write the problem on a piece of paper? Can you translate these words into symbols? Now, can you add, subtract, multiply, divide?' I take it a step at a time. And sometimes, what I find is a really, really bright kid who will say he never learned to divide. Maybe he was sick when his classmates learned long division. But he never picked it up—and he's been anxious about math ever since."

Buhrman likes to use real-life examples to make math exciting. She has had precalculus students figure how far a skateboarder will skid when he tries to stop, depending on his velocity. She has ordered pizzas for geometry classes to let students measure the areas under segments of a circle. (She's had to order two pizzas—one to measure and one to munch.)

She has started several programs in Carroll County, including a walk-in clinic where students can be tutored after school. Students who come may find they can relate better to a different teacher, and teachers benefit by being challenged to stay fresh in a variety of math topics. "You can't succeed with all kids all the time," she says. "But there is a lot teachers can do to make a difference."

In Caporello's school system, math teachers are trying to help each other improve skills. Next year, an NSF grant will enable Virginia Bastable, a graduate of WPI's Master of Mathematics (MM) program, to serve as a math consultant to the system. Bastable will co-teach, make suggestions, help plan lessons—anything a teacher believes will improve the class.

Caporello and a few other Amherst teachers participated in a summer math program at Mt. Holyoke College. Now they observe each other's methods and have weekly discussions about math teaching. Caporello hopes to see this model extended throughout the school system. "Maybe it's time to reinstate an old model, where several teachers teach as a team. One person really well-versed in math could help two or three others improve," adds the 1988 graduate of WPI's MM program.

Unlike many graduate programs for math teachers, WPI's master's program focuses only on math, not on education. Attracting teachers from across New England, it gives them an opportunity to study math as a new, unfolding discipline and to digest the latest research.

Graduates of the in-service program say WPI made them better teachers for two reasons: the intense regimen of classes every Tuesday for four years kept them constantly aware of how their own students felt; and the rigorous study of math gave them a deep and broad understanding of their field.

"I see the results of that education when I go to conventions," Caporello says. "I went to one recently where the person who was giving a talk was using blocks to demonstrate fundamental math principles. To a lot of teachers, what he was doing was a revelation. To those of us who had more math, it was common sense. It's hard to give kids an appreciation for what math is, if you don't have it yourself."

As head of the math department at Rocky Hill, Coes is responsible for instilling that appreciation for math in all of his teachers. He also serves as president of the Rhode Island Mathematics Teachers Association, making him a state leader in the field.

Coes entered math teaching in a roundabout way: He studied English in college, taught elementary school, then pinch-hit in a high-school math class. He enjoyed the job so much he stayed on as a math teacher. After graduating three years ago from WPI's MM program, he was honored with a Presidential Award as one of the two best math teachers in Rhode Island.

Recently he was asked to testify before Congress about American math education. He talked about what works for him. He talked about the need for better-educated math teachers. His recommendations to

Congress paralleled those made by government agencies and educators at every level of the system:

- Have all children study math every year, kindergarten through high school.
- Rethink the way grade-school math is taught; in particular, place more stress on concepts and less on computations.
- Allow students to use computers and calculators to learn math. Some schools do this already, but many are only beginning to buy enough computers to make using them practical in math instruction.
- Provide more teacher training in math for elementary-school teachers. Currently 70 percent of those teachers have had no college-level math, and 80 percent have had only one course past junior high.
- Teach all students probability and statistics, which would make math more relevant to the real world. Traditionally, those topics are relegated to the back of textbooks. As a result, few teachers get around to presenting them. We should not just prepare students for the SATs, Coes said, but we should promote math literacy.
- Don't rush high-school students, even bright ones, into calculus. Sometimes the push to squeeze calculus into a high-school education denies students an opportunity to master algebra, geometry, and trigonometry—the basics upon which calculus is built. It also deters them from seeing real applications of mathematics at an early level and discourages them from continuing in math.
- Reverse the current funding structure, through which the NSF and other federal agencies provide the greatest support in math to colleges, a lesser amount to high schools, and almost none to elementary schools.
- Have kids work together. They can study in teams and still be tracked individually.

"The best students—the top 10 percent—are better than they've ever been," says Marie Tangney, a teacher at Doherty Memorial High School in Worcester and WPI's first Visiting Mathematics Scholar. "But below that, even the average students seem to have less competence in the basics. We need to help them."

Tangney believes math drills that help students memorize the basics are essential, but she thinks computers and calculators can serve as important tools after students are mathematically literate.

"They are like any other tool—you can use them as a crutch or as a tool to increase your understanding. I see no reason to require students to use pencil and paper to multiply one three-digit number times another three-digit number."

The United States puts too little emphasis on the importance of a strong math education, she thinks. And she says national debates about a math crisis do little to solve the problems if the government doesn't commit to fund solutions to the national crisis dubbed "innumeracy."

"We're talking about young people who we hope will live another 50 to 60 years as contributing members of our society—a society that is getting more and more technical. We need to make sure all of our people are mathematically literate. We send mixed messages to kids when we talk about the importance of math, then lay off teachers in favor of keeping other city employees on the job."

Any change in math education needs to address the problem of math anxiety, she says. "About 75 percent of all people today will see a math problem and be scared to death. A lot of them won't even try it."

Villanova University Professor Michael Levitan encountered so many students suffering from math anxiety that he designed a workshop to tackle the problem.

Levitan, who teaches graduate students in applied statistics, finds students of every age and background enrolling in his workshop, in which he asks them to confront their fears and examine them as a group.

"I don't promise I'll make them good at math or even like it. I'm not trying to teach math. I'm trying to make them realize they can deal with it if they choose to."

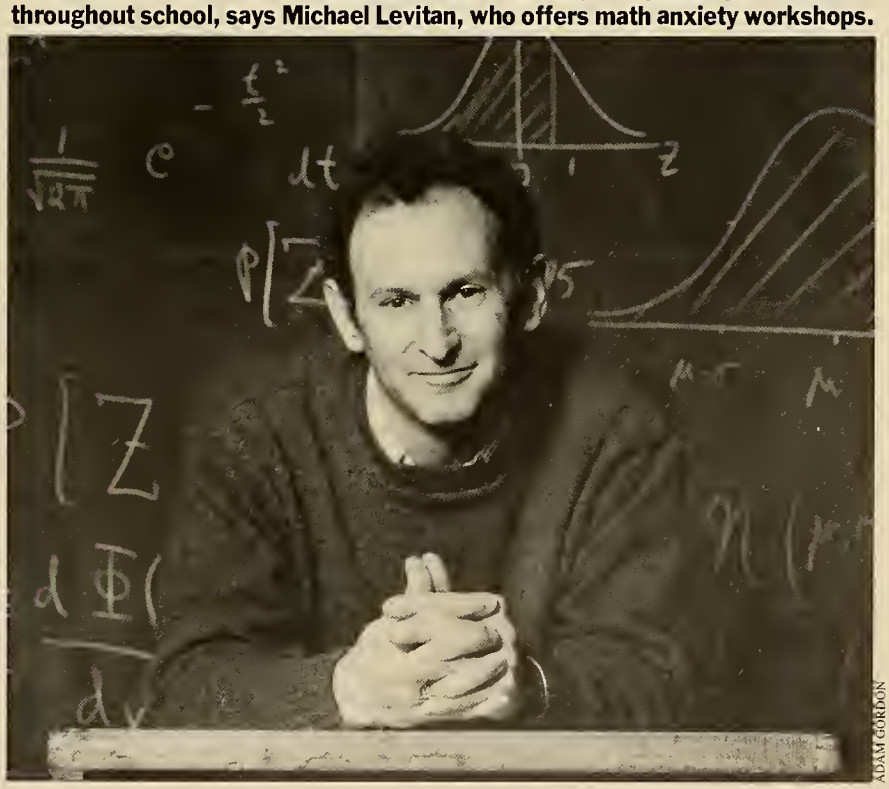
He has learned some surprising and not-so-surprising facts about math anxiety: More women than men admit to it, although both groups seem to suffer from it. The difference, he says, lies in the way the two groups express their feelings—women say they can't do math; men say they could do math if they wanted to, but they don't.

Children learn to fear and hate math at every stage of the educational system, from first grade through high school, he says. Most, however, start out liking math, until they fall behind, or are thrown by a course they consider tricky—like algebra.

Caporello agrees. "It's really hard to separate out those kids who hate math because they lack ability and those who have just missed something along the way. "You try to renew their enthusiasm if you can. You try to make your class a place where they can succeed. You try to let them see that math is just like anything else—some people are good at it, some people like it, and some people don't. Either way, you try to make them aware of how important math is to their own success. Sometimes you get through. That's when you both succeed."

Lisa Hooker is a Baltimore science writer.

For many youngsters, a fear of numbers starts early and picks up momentum throughout school, says Michael Levitan, who offers math anxiety workshops.



ADAM GORDON

Oh, FOR A BOOK and a SHADY NOOK

Heading for a hammock? Stretch out with some spellbinders from cultures near and far. By Leslie Brunetta

Summertime, and the livin' is easy. At least easier, most of us hope—a time to bask on porches and balconies, to unwind by the shore. And for many of us, a time to savor long, lazy hours spent reading some of those books that we never seem to have time for the rest of the year.

For those who demand of their summer reading, as Sir Philip Sidney demanded of poetry, that it should both teach and delight, the following list has been compiled, drawing from faculty and alumni recommendations. The criteria were simple. Each book had to offer an entrée into a culture off the beaten paths followed by college core curricula or the entertainment industry. And each had to be either enjoyable or gripping—in other words, a great summer read.

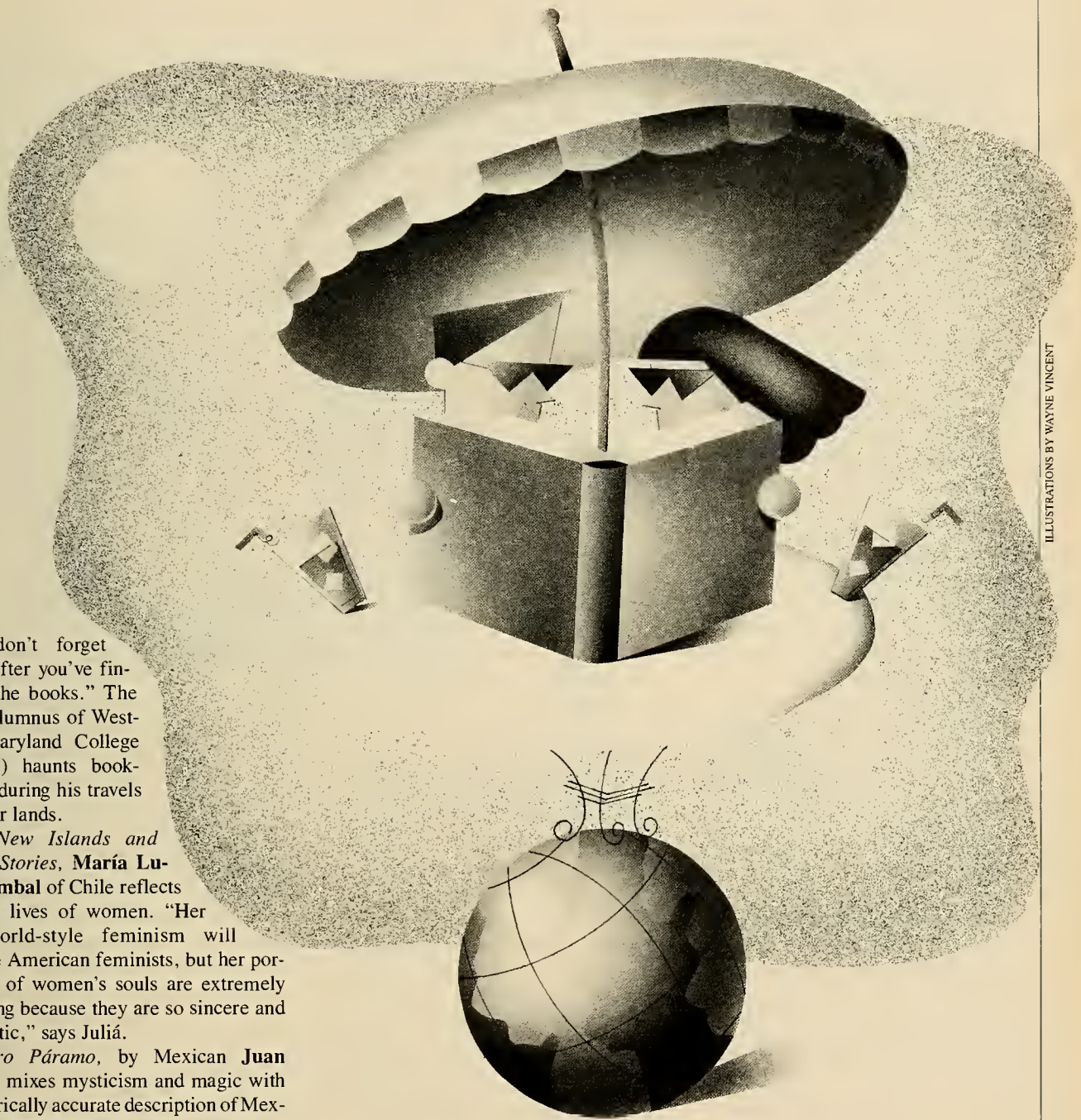
South of the Border: Old and New Worlds Clash

We in the United States share the hemisphere with countries almost unknown to us. Those who have gained a glimpse of the world—real and imaginary—south of our borders through the mesmerizing prose of Gabriel García Márquez, Carlos Fuentes, or Mario Vargas Llosa are sure to enjoy the works of these Central and South American writers.

El Inca Garcilaso, who died in the same year as Shakespeare, is considered to be the first great American-born writer. The son of an Incan woman and a captain in the Spanish army, he represents the cultural clash of conqueror and conquered in Latin America, says Mercedes Juliá, assistant professor of modern languages and literatures at Villanova University. Garcilaso didn't learn Spanish until he left Peru at age 12 to seek his father's family. In Spain, he wrote the *Royal Commentaries,* which Europeans for more than 200 years considered to be the established history of the native Peruvians, the Incas. But fairly recently, scholars have discovered otherwise. "What Garcilaso did was to invent a wonderful story in order to save his own people and to restore the dignity he thought the Spanish had taken away from them," says Juliá, a native of Spain. "As fiction, the *Commentaries* are a beautiful narrative written in a Renaissance prose, styled by a genius," Juliá continues.

The chasm between Peru's Spanish and Incan cultures has extended well into the 20th century, finding expression in *The Deep Rivers,* the 1958 novel by **José María Arguedas**. A blond, blue-eyed lad of Spanish ancestry, Arguedas was raised by his father's Indian kitchen servants after his mother died. When his father sent him to school at age 12, his peace of mind was shattered. His novel recounts the story of a boy who looks Spanish to everyone around him, but who sees everything from an Indian perspective. "This novel opened my eyes more than any other to the culture of the Peruvian Indians," says Juliá. "It's a lyrical novel that allows us to feel with the innocence of a child the beauty of the Indian world."

Brazil's **Jorge Amado** looks at the confrontation between the old values of the landed classes and the new values of the entrepreneurs in *Gabriela, Clove and Cinnamon*. And in *Captains of the Sand,* he writes of homeless boys living in the country's poverty-stricken northeast. Another Brazilian, **José Lins do Rêgo**, developed a series of novels during the 1930s and '40s recounting life on and around the vast sugar cane plantations. The series culminated with his masterpiece, *Dead Fire*. Says Edward Nygren, who lived in Nicaragua while a Project HOPE surgeon, "These novels are about people with problems you can believe.



ILLUSTRATIONS BY WAYNE VINCENT

You don't forget them after you've finished the books." The 1947 alumnus of Western Maryland College (WMC) haunts bookstores during his travels to other lands.

In *New Islands and Other Stories*, **María Luisa Bombal** of Chile reflects on the lives of women. "Her Old-World-style feminism will trouble American feminists, but her portrayals of women's souls are extremely touching because they are so sincere and authentic," says Juliá.

Pedro Páramo, by Mexican **Juan Rulfo**, mixes mysticism and magic with a historically accurate description of Mexico's land problems, says Sharon Scinicariello, director of foreign language studies at Case Western Reserve University (CWRU). The novel's central character goes searching for his father and finds a city where the voices of the dead reveal, bit by bit, the story of Páramo, the town boss. Juliá is also a fan of Rulfo: "Rulfo became a father of Latin American literature virtually overnight when this novel appeared in 1955. Spanish had never been used before to render so many meanings at once."

Tales of Japanese Treasures, Tea, and Trade

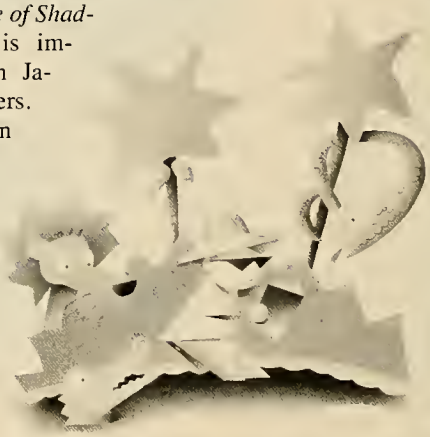
In Japan, business professionals and politicians read American fiction to learn how we think. It's about time we applied the same principle, says Robert Chambers, president of WMC, who taught in Kyoto for a semester in 1983. "The Japanese are much more open to learning about the West than we've been to learning about them, and we're paying the price," he believes. For a good overview of Japanese culture and society, Chambers recommends two books by Americans: *The Japanese*, by **Edwin Reischauer**, a former ambassador to Japan who has lived there off and on for more than half his life; and **David Halberstam**'s *The Reckoning*, which compares the Ford Motor Company with Nissan, along the way detailing the political, financial, and

social forces that help to explain our trade gap with the Japanese.

But the best way to begin to understand Japanese culture, says Chambers, is to read literature by Japanese writers. The extremes of **Yukio Mishima**'s life—his reactionary political beliefs, his band of fanatical "warrior" followers, and his public commission of hara-kiri in 1970—as well as his beautiful prose and homoerotic themes have made him the most widely read Japanese author in America. "Mishima was an embarrassment to the Japanese," says Chambers. "He seemed a throwback to the samurai tradition at a time when Japan was trying to conform to post-war Western standards. But at the same time, his flamboyance and egocentrism were very American, very un-Japanese. And he writes like an American: While many Japanese writers are big on suggestion and silences, his novels—such as *Spring Snow* and *The Temple of the Golden Pavilion*—have lots of description thrown in. He reads like a Japanese Faulkner."

While Mishima may have been an embarrassment, novelist **Natsume Soseki** was considered a national treasure—in fact his portrait graces Japanese currency. "If you could read only one Japanese novel, Soseki's *Kokoro* should be it," says Chambers. *Kokoro* tells of an esteemed older teacher, admired by a younger student. The teacher's intense unhappiness stems from something in his past, something tied to betrayal, to greed, to family relationships, and even to East-West relations. "I've never encountered an American reader who didn't love it," says Chambers, "and it's been read by virtually every Japanese adult."

Junichiro Tanizaki is another modern Japanese hero. Two of his novels, *The Makioka Sisters*—about an Osaka family's attempts to find a husband for a daughter—and *Some Prefer Nettles*—focusing on a couple deciding whether to divorce—concern sexual and other relations between men and women, as well as Japan's rapid modernization. Tanizaki's preoccupation with new Western influences on Japan also spawned his 1933 essay, *In Praise of Shadows*. "This book is immensely famous in Japan," says Chambers. "Tanizaki sees Japan changing too quickly, and as he writes about everything from fountain pens to toilets, he decries what he sees as the country's cultural decline."



Mishima, Soseki, and Tanizaki made rapid change in modern Japanese society the grand subject of their art. But indigenous customs and beliefs still survive in post-war Japan, and two classic Japanese essays can help the Westerner to understand them. About 300 years ago, the samurai warrior **Miyamoto Musashi** wrote *A Book of Five Rings*. Samurai swordsmanship was the physical manifestation of a philosophy central to Japanese culture, and so is still closely related to modern-day methods of strategic thinking. If you want an insight into how Japanese people might approach business deals, says Chambers, this is the essay for you.

Kakuzo Okakura's essay, *The Book of Tea*, began to take shape in Boston, where Okakura lived during the early 1900s. He found that few Americans knew anything about Japan. "He decided to explain his country by describing the tea ceremony from every perspective—where the tea came from; the rituals of serving, pouring, and drinking it; what tea as a substance means to the Japanese; and what it could conceivably mean to the West," says Chambers. In about 50 pages of exquisite prose, Okakura reveals the Japanese reverence for history, beauty, and ritual.

Africa: Black and White

Due to censorship rules imposed by its government, South Africa appears less frequently in American news reports than it did a few years ago. But the apartheid system and the struggle against it continue. Apartheid is perhaps the most visible legacy of Europe's colonization of Africa, but the shadow of European domination lingers on even in the black-ruled nations. Not surprisingly, much of the continent's literature reflects the confrontation of blacks and whites, of the traditional and the foreign.

Most South African literature available in the United States tells of that nation's problems from the viewpoint of white dissidents. The novels of **J.M. Coetzee** are no exception. But those already familiar with the fiction of Nadine Gordimer and Alan Paton, South Africa's most internationally known writers, will find that Coetzee's allegorical approach allows him to probe that country's wounds with perhaps an even sharper stick. "*Waiting for the Barbarians* is about life at a fictional frontier," says John Trimbur, associate professor of English at Worcester Polytechnic Institute (WPI). "It gives you some idea of the garrison mentality of the white community in South Africa, of how they can only see their perceived enemies as something other than themselves."

Fans of drama should try *"Master Harold" . . . and the Boys* by **Athol Fugard**, recommends Charles Heventhal, who is also a WPI associate professor of English. The play, set in the 1950s, has just three characters: Hally, a white teenager ashamed of his alcoholic father, and Sam and Willie, two black men who work in the restaurant run by Hally's parents. During a long, rainy afternoon

in the restaurant, the three discuss their memories and dreams for the future, until Hally turns on Sam, his substitute father. "The question is whether Hally can become his own person or will accept the norms of the white society. It's a short play, but wonderfully crafted and compelling," says Heventhal.

Nigeria's **Wole Soyinka** won the Nobel prize for literature in 1986, whetting many people's interest in the continent's literature. "Soyinka's play, *The Lion and the Jewel,* shows sensitively and humorously the conflict between the old and the new in modern Nigeria," says Walter Strauss, professor of modern languages at CWRU.

Anthills of the Savannah, Nigerian **Chinua Achebe**'s novel about an African coup, made lots of "the year's best novels" lists in 1988. Achebe is probably best known for his 1958 novel, *Things Fall Apart.* "People who liked *Shogun* or Michener would like this book," says Con Darcy, chairman of WMC's history department. "Although it's less than 200 pages long, it's a remarkable depiction of a historical landscape peopled by vital figures. Achebe gives you a vivid portrait of traditional Ibo life and of the changes brought by whites."

While Soyinka and Achebe describe life in what was once British Africa, other African writers tell of the formerly French territories. **Camara Laye**'s *The Dark Child* touchingly recreates his childhood in Guinea. *Mission to Kala,* by Cameroon's **Mongo Beti**, centers on a young man who must travel to a small village in the interior to bring back a young woman who has run away. The story is really about the confrontation between the hero's big city ideas and the village's traditional customs, says Darcy: "It's told with lots of comedy—it's a picaresque novel in an authentic African setting."

Glimpses into India's Native and Colonial Cultures

The international uproar surrounding **Salman Rushdie**'s fantastical novel, *The Satanic Verses*, may lead people to read his 1981 novel, *Midnight's Children*, a magical recounting of India's history since Independence. This winter, when Iran's Ayatollah Khomeini denounced the London-based author as a blasphemer of Islam and sentenced him to death, Rushdie became the best-known name in Indian literature outside that country. But Rushdie is just one among many contemporary writers to document the Indian experience in fine fiction, says P.K. Saha, associate professor of English and linguistics at CWRU.

Mulk Raj Anand, whose books were extremely popular during the 1930s and '40s, wrote many novels about India's poor. The one that first brought him renown, *Untouchable*, follows a day in the life of a street sweeper whose ideas about living, society, and destiny have been transformed by Gandhi's teachings.

Until this year, **R.K. Narayan**'s musical prose and gently comic treatment of life in his native land made him the most famous Indian writing in English. Of his many novels, Saha particularly recommends two: *The Guide*, about a scoundrel who suddenly finds himself taken as a holy man; and *Waiting for the Mahatma*, the story of Gandhi as seen from the point of view of a volunteer worker, a character who represents the masses of India.

Saha's favorite English-language Indian novelist in the generation between Narayan and Rushdie is **Anita Desai**, whose father was Bengali and whose mother was German. Her best-known works include *Fire on the Mountain* and *Clear Light of Day*, both exquisite evocations of life in a former colony struggling to define its own identity.

Following the old and new trade routes, Indians have emigrated all over the globe, taking along with them beliefs and practices from native and colonial cultures. One of the youngest Indian writers to conquer the West, says Saha, is **Bharati Mukherjee**, now living in North America, who frequently sketches the lives of people who are never really at home. Her most recent collection, *The Middleman and Other Stories*, won the 1988 New York Book Critics Award.

Beyond the Conventional on the Continent

We may think we know the European classics—Cervantes's *Don Quixote*, Dostoevsky's *Crime and Punishment*, Flaubert's *Madame Bovary*, among other stalwarts of the college survey course. But some works that Europeans have always considered classics are virtually unknown even to educated Americans. Along with an impressive array of contemporary works, these great books are finally making their way into our hands as more European literature than ever before is being translated into English.

Ivan Goncharov was Dostoevsky's contemporary, and his novel *Oblomov* brought him worldwide acclaim. "It's one of those novels that's really important in Russian literature, but that nobody ever reads," says Scinicariello at CWRU. "But once you read it, you never forget it." Oblomov spends his time in a state of perfect passivity, achieving a near total peace of mind. "It takes him the first 50 pages just to stick his foot out of bed," adds her colleague, Walter Strauss. "Maybe because we all have to be so active, Oblomov's tranquillity makes him an unforgettable character."

Two recently translated Spanish novels of the 1880s are bound to take their rightful place in American curricula, according to Villanova's Juliá. *La Regenta*, by **Clarín** (the pen name of Leopoldo Alas y Ureña) focuses on a beautiful woman looking for meaning in her life. Two men—one a priest—fall in love with her. Her travails suggest the era's social, political, and philosophical atmosphere. "It's written so magnificently and with such irony that it's a masterpiece, very much along the lines of *Madame Bovary,*" says Juliá. In *Fortunata and Jacinta*, by **Benito Pérez Galdos**, a married, upper-class man falls in love with a poor woman. The story then follows his sometimes desperate struggles with his wife and his lover, as well as their relationships with a host of sec-

ondary characters. Says Juliá, "This is one of those books that's so real that you enter into the characters' world. You get to know the politics, the customs, the way of life. A friend told me that when Fortunata cried, he felt sick himself."

From 20th-century Europe comes a variety of works reflecting its political, philosophical, and artistic developments.

France's **Michel Tournier** questions traditional ideas of narrative and authority in his novel *Friday*, the Robinson Crusoe story told from a different point of view. **Claude Simon**, winner of the 1985 Nobel Prize for literature, was one of the original exponents of the "new novel," which attempted to overturn conventional assumptions about the narrative form. "His novel, *The Flanders Road*, is a good introduction to a different type of novel for those who don't want anything too esoteric," says Strauss.

Strauss also recommends the work of Italy's **Italo Svevo**, a friend of James Joyce, whose *The Confessions of Zeno* "is an ironic extravaganza about a modern Italian intellectual type." His other favorite authors include **Primo Levi**, much of whose work looks back on his experiences as a prisoner in Auschwitz; and **Italo Calvino**, whose *Invisible Cities*, with its conversation between Kubla Khan and Marco Polo, is "a splendid fantasy about imaginary cities that are also real in a way."

Germany's **Alfred Doblin** and Austria's **Peter Handke** are favorites of Trimbur at WPI. Doblin's two-volume historical novel, *November 1918*, portrays the political, economic, and social dislocations of the immediate post-war period. "You can see exactly where Hitler is going to come from," says Trimbur. Handke's *Short Letter, Long Farewell* fictionalizes a German hippie-outsider's trip across the United States, while in *A Sorrow Beyond Dreams*, Handke reflects on his mother's suicide. Trimbur says, "It's an incredibly powerful essay."

From Spain comes **Miguel Delibes's** 1966 novel, *Five Hours with Mario*. "I think he's the best Spanish writer of the last part of this century," says Villanova's Juliá. "This novel follows the thoughts of a woman who sits beside her husband's body for five hours, recounting their life together. He was an intellectual and she's more interested in petit bourgeois things, so it's largely about the many misunderstandings they had." Juliá also recommends the poems of 1956 Nobel Prize winner **Juan Ramon Jiménez**, especially if you can read them in the original Spanish (she did her dissertation on Ramon's "Espacio").

Soviet and Eastern European writers are often forced to turn to allegory to get their texts past the state censors. A realistic story, such as **Anatoli Rybakov**'s *Children of the Arbat*, risks suppression, says Nancy Palmer, senior lecturer in English and comparative literature at WMC. "The novel has several narrative lines, each describing how Stalin's rule affects different kinds of people living in Moscow's Arbat neighborhood. It talks about the purges and other horrors of the period, which is why it was censored for over 20 years."

Czechoslovakian playwright **Vaclav Havel** has spent a total of more than five years in prison since the 1968 Soviet invasion of that country, and was recently sentenced to nine more months for leading a demonstration marking the invasion. Although Havel's plays are often produced in the West, not one has been staged in his own country since 1968. Havel's 1965 play, *The Memorandum*, a universally understandable satire about an incomprehensible bureaucracy, offers Western readers an insight into life under such an oppressive political system, notes WPI's Heventhal.

As it hovers beyond the bounds of reality, science fiction almost always contains an allegorical version of human experience. Perhaps the Eastern bloc's lack of intellectual freedom and the resulting need to bury real meaning explain why some of the world's best contemporary sci-fi springs from behind the Iron Curtain. Lance Schachterle, chairman of WPI's Interdisciplinary Studies Division, observes that few writers can match the wit of Soviet brothers **Arkady** and **Boris Strugatsky.** Their short stories examine how scientists look at problems, and how scientists and others are conditioned by the society around them. He particularly recommends *The Time Wanderers* and *Inspector Glebsky's Puzzle*.

Poland's **Stanislaw Lem** is the Eastern bloc's best-known sci-fi writer. "He's very broadly educated and his works have a great philosophical depth," says Schachterle. "He tells a lot about the way scientists think and about how we fit technology into our lives." Lem's *Solaris* is about researchers who discover and then try to explain a planet that seems to be a living organism, while *The Cyberiad* is a collection of very funny stories about intelligent computers whose adventures are modeled on the ancient epics. According to Schachterle, "Both the Strugatskys and Lem write great fiction that just happens to fit the science-fiction definition."

Voices from Troubled Times

Allan Bloom and other would-be reformers complain that our educational institutions are ignoring the classics of Western literature in favor of texts by African-Americans and other members of minority groups. It may be true that fewer people now read the "great books." But, beyond perhaps Ralph Ellison's *Invisible Man*, Richard Wright's *Native Son*, Alice Walker's *The Color Purple*, or Toni Morrison's *Beloved*, it's also true that all too few Americans read—or even know about—the classics of black literature.

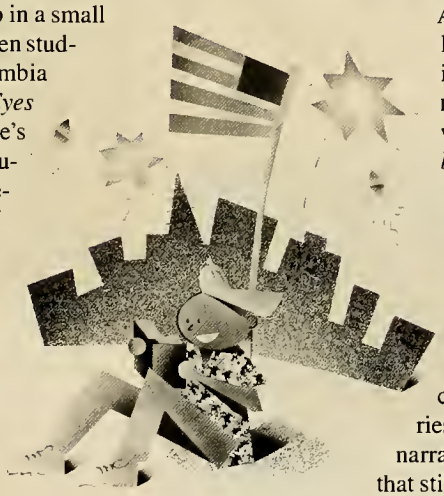
"*The Narrative of the Life of Frederick Douglass* is the sire of the whole African-American literary tradition," says Michael Berthold, assistant professor of English at Villanova. After escaping from slavery, **Frederick Douglass** came forward as one of the great intellectual and political leaders of the abolition movement and of the African-American com-

munity after emancipation. "The autobiography is an essential text for any understanding of American culture or literature as a whole, and it should be read by all those who consider themselves educated Americans," Berthold adds.

Incidents in the Life of a Slave Girl, by **Linda Brent**, is the female counterpart to Douglass's narrative. The girl of the title is subject not only to the acknowledged hardships of slavery, but also to sexual domination by her owner, an injustice now known to have been a commonplace in the lives of slaves. Brent hides in an attic for seven years before finally making her escape. "This is an absolutely gripping narrative, and again a text that every educated American should have read," Berthold says.

W.E.B. Du Bois, a leader in the movement for social reform for nearly 60 years, wrote *The Souls of Black Folk* in 1903. "This is written in wonderfully classical rhetoric, but it's absolutely contemporary in its description of the struggles and contradictions inherent in black life in this country," says WPI's Trimbur.

For those who enjoy the work of Walker and Morrison, the long-neglected novels of **Zora Neale Hurston** should be a great discovery. "Walker and others very consciously brought Hurston back into the public eye because they saw her as their literary godmother," Trimbur explains. Hurston grew up in a small Florida community and then studied anthropology at Columbia University. "In *Their Eyes Were Watching God*, she's writing of her own community, but with the somewhat more critical eye of the anthropologist," says Berthold. "It's a great love story about a woman's attempt to find herself and to find love."



Berthold recommends two other 20th-century novels. *Mumbo Jumbo*, by **Ishmael Reed**, is for the more adventurous reader. He notes, "It's a surrealistic brooding on 200 years of black experience in America." And *Dessa Rose*, by **Sherley A. Williams**, he describes as "a 20th-century reexamination of slavery, a more explicit and contemporary version of what Linda Brent was writing about."

Suspicion still lurks among some readers that many recently unearthed works by women writers have been dredged up for political rather than aesthetic reasons—that the books disappeared in the first place because they just weren't all that good. Anyone reading the following works will soon cast aside such doubts.

Fanny Burney enjoyed immense fame during her own lifetime, once it was revealed that she was the anonymous author of the 1778 novel *Evelina*. "Anyone who likes Jane Austen would adore Burney's novels," says Marie McAllister, assistant professor of English at Villanova. As Evelina's story is told through letters, the virtuous but naive young woman from the provinces makes her way through the rituals of London society before finding happiness married to a wise and kind man. Along the way, she confronts a long series of sometimes vulgar, sometimes cunning men, as well as a grandmother who keeps trying to marry her off for money. "It's the 18th-century version of the dating game," says McAllister. "Burney is incredibly witty, and she also allows a little more anger and violence to surface than Austen does. It's interesting to think about why and how a woman of that pre-feminist age expresses such anger."

Almost 50 years later, in America, **Lydia Maria Child** wrote *Hobomok*, about an upright Puritan girl who rebels against her own family and the Puritan male hierarchy. "She marries an Indian, a narrative moment that still has the power to outrage even in this century," says Villanova's Berthold. **Catharine Maria Sedgwick's** 1827 novel, *Hope Leslie; or Early Times in Massachusetts*, is another proto-feminist consideration of wilderness life.

The names of **Harriet Beecher Stowe** and her contemporary, **George Eliot**, are still well-known to most American readers, but few people, once they're out of high school, actually read either author. That's a shame, say those who as adults have relished their works. "*Uncle Tom's Cabin* has been completely reconsidered in the last 10 years, and has been redeemed from its reputation as merely a sentimental and schlocky romance. It's a great read," says Berthold. And Eliot has been "rediscovered" by feminist critics as one of the great chroniclers of female experience, adds McAllister, whose specialty is British women writers of the 18th century. "She gives depth to her women characters that men writing at the same time simply didn't," McAllister notes. "She paid more attention to the psychological aspects of both her male and female characters than just about anyone up until Henry James."

Even those on familiar terms with Ezra Pound and T.S. Eliot may know little or nothing about **H.D.** (Hilda Doolittle), who ranks with Pound as probably the most successful of the Imagist poets. H.D. was born in Pennsylvania and followed Pound to London, where she had a hand in virtually every literary development of importance from 1910 through the 1920s. *Bid Me To Live* is a thinly veiled autobiography about her years in London with Pound, D.H. Lawrence, and Richard Aldington. H.D. was also one of Freud's first patients; her book, *Tribute to Freud*, reflects on those sessions. "It's a fascinating, very personal account in her own unique style about her analysis and about analysis in general," says Laura Jehn Menides, associate professor of English at WPI. "She disagreed with Freud quite often, especially about his theories on women, but he helped her come to terms with her childhood and her sexuality." Menides also recommends the new edition of H.D.'s poems to modern poetry fans.

Each work is in print and should be readily available at better book stores and at libraries. Happy reading!

Leslie Brunetta's most recent article for the AMC was about lasers.

Sequestered in Suburbia

More working women. Fewer children. Long commutes. Are suburban neighborhoods losing their niche in the American landscape?

By Sue De Pasquale

In the late 1970s, during the early years of their marriage, Larry and Susan Finkelstein lived in a brownstone apartment in downtown Philadelphia's Society Hill section. Other couples nearby were also young professionals, so the Finkelsteins didn't have to look far for friends: They fell easily into an informal network of parties and get-togethers.

Once Susan gave birth to Eric in 1981, the couple's priorities shifted. They wanted to live in a neighborhood of single-family homes—someplace with a solid school system, where Eric could play freely outside in the yard and make friends with other kids on the block. Both Larry, an attorney, and Susan, a speech pathologist, had grown up in close-knit communities in Queens, New York, so the two 1973 Western Reserve College (WRC) graduates returned to New York to find a home.

"As a child, I knew all the kids on the block. My son doesn't," says Larry Finkelstein (WRC '73), here with wife, Susan (WRC '73), and Eric.

DOUG McDONOUGH

It didn't take them long to discover that the flavor of neighborhood life in Queens had changed. "We've lived in Jamaica Estates for five years now," says Larry, "and the people on our street are not people we know very well. My wife grew up on a street where the neighbors sat outside and chatted. Here, most of the neighbors are gone during the day." Susan's job is just seven minutes away, but Larry rarely sees his yard in daylight; he starts his 90-minute commute into Manhattan shortly after sunrise and returns home around 8 each night.

Seven-year-old Eric has fewer neighborhood playmates than Larry had expected: "As a child, I knew all the kids on the block and played with them. My son doesn't have that same experience. There aren't as many children on our street, so his playing time is more structured. There are more arranged dates as opposed to kids just coming by and ringing the doorbell."

In many suburbs across America, the days of block parties and neighborhood cookouts, of front porch chats and backyard games, seem to be waning. The microwave has replaced the barbeque, and the health club workout has supplanted the evening stroll. At a time when "cocooning" is the byword, couples are content to remain within the walls of the comfortable suburban nests they've feathered with VCRs and CDs, Jacuzzis and security systems. Most of today's Baby Boomers, say social scientists, have neither the time nor the inclination to forge close ties with their neighbors.

DOUG McDONOUGH

Rather than rent in an apartment complex, Karen Rex (WMC '87) headed home to Chatham to live with her parents.

"As we enter into the 1990s," predicts Dan Rees, professor of sociology at Western Maryland College (WMC), "I believe neighborhoods will become more and more like ghost towns, with people gone during the day."

Consider this: In 1960, when today's young professionals were pre-schoolers watching *Captain Kangaroo,* most of their moms were home to make their lunches. Only 40 percent of women with children worked full-time outside the home. During those years, it wasn't too much of a stretch for a suburban, middle-class family to get by on one income. In the 1950s, the average 30-year-old homeowner could meet a monthly mortgage payment using just 14 percent of before-tax pay, says Frank Levy of the School of Public Affairs at the University of Maryland. In 1973 the monthly note took 21 percent, but by 1984 it was consuming 44 percent. As a result, of all first-time homebuyers last year, 85.5 percent were two-income households.

With women streaming into the workplace (more than 60 percent now work outside the home), the glue that traditionally held neighborhoods together has dissolved, says Linda Copel, assistant professor of nursing at Villanova University and a therapist specializing in marriage and family counseling. "Women historically have been the 'social maintenance people' of the suburbs," she explains.

Stranded at home all day—usually without a car—suburban housewives of the 1940s and '50s could devote their fullest energy to their families and to the people and projects within walking distance. They knew when their neighbors took sick or were available to baby-sit on short notice.

Of course, not everyone at the time embraced this lifestyle with enthusiasm. Some social scientists were concerned that individuality would be deadened by the uniformity of suburbs inhabited by people of almost exactly the same age, income, and background. "Mass-produced, standardized housing breeds standardized individuals, too—especially among youngsters," psychologist Sidonie Gruenberg warned in a 1954 issue of *The New York Times Magazine*. Women, in particular, felt cut off—from the daily lives of their husbands and from the diversions inherent in city living. Many found their suburban sphere of existence too limiting.

"Today women have changed their focus," says Copel. "There are other places where they can go and get the things they once got from their neighborhoods." On the job eight and nine hours a day, women are looking to their colleagues—rather than their next-door neighbors—for friendship and social interaction. Once they do get home, many female professionals are physically and mentally drained: a full day's work, plus running errands and picking the kids up from daycare, doesn't leave much energy to host a dinner party or a bridge game.

For both women and men, the nature of work itself has changed over the last three decades. Today's two-career couples put in long hours on the job—after time-consuming commutes—and then end up bringing work home with them. And regular travel is a requirement in many careers.

Historically, women were the "social maintenance people" of the suburbs, as seen in this 1928 advertisement in *Ladies' Home Journal*. Today their focus has shifted to the workplace.

ADAM GORDON

With women streaming into the workplace, the glue that traditionally held neighborhoods together has dissolved, says Villanova therapist Linda Copel.

Take the case of Edward Gonsalves, an applications engineer for North American Phillips Corporation, who lives with his wife, Paula, and their 18-month-old son, Matthew, in a suburb of Fall River, Massachusetts. They've owned their home for six years. Gonsalves spends a good deal of his time in transit, calling on manufacturers in Canada, Puerto Rico, and Europe to demonstrate his company's services. The constant traveling leaves the 1981 graduate of Worcester Polytechnic Institute little opportunity to socialize with his neighbors. But then, they're caught up in the demands of their own lives anyway.

Gonsalves's current neighborhood contrasts sharply with the Somerset, Massachusetts, community in which he grew up, where "there was a real sense of cooperation," he says. Like his own parents, most of the families on his street were first-generation Portuguese immigrants. "My father was a laborer and my mother was a sewing machine operator in a local mill," Gonsalves explains. "They would work long hours, but when they came home, their jobs were finished. I remember summer nights when my dad would get together with the other men and talk about things. When his lawn mower broke, he'd just borrow the neighbor's. That sense of community doesn't exist where I live today. I really enjoyed that and I miss it."

Traditionally, children have provided the link that draws together nearby young parents who otherwise might not realize they have something in common. "We weren't extremely friendly with the neighbors next door, until we started our family," recalls Gonsalves. Once their toddlers became playmates, the two couples began going out together on weekends. Gonsalves notes, however, that there are only a handful of families on his block who do have small children—a far cry from his childhood neighborhood.

Couples today are waiting longer to buy their first homes and to start their families, and they're having fewer children once they do. In 1977, the median age of a first-time homebuyer was 26, according to a U.S. League of Savings Institutions survey. A decade later, that median age had jumped to 31.5. Saving enough money for the down payment on a starter home—which can run between $100,000 and $200,000 in many markets—clearly takes time. Gonsalves himself lived at home with his parents for several years after college before he and his wife got married and bought their home.

Economic constraints are also limiting the size of families, says demographer Joseph McFalls Jr., associate professor of sociology at Villanova. It costs today's average middle-class family between $50,000 and $100,000 to raise a child.

American couples are reproducing at a rate that will yield an average of 1.8 births, less than the 2.1 births needed to replace their generation in the population, McFalls pointed out in his 1981 article in *USA Today*, headlined "Where Have All the Children Gone?" Among young professional couples, he says, that average birth rate dips to 1.4. "In yuppie neighborhoods, children are few and far between," McFalls says. "This is having a tremendous impact

BOB THAYER

because kids can't just topple out of their houses anymore and find a friend."

In the absence of casual play encounters for their children, suburban parents—like the Finkelsteins in Queens—have to look beyond their immediate neighborhoods. To make sure Eric spends time beyond school hours with other 7-year-olds, Larry and Susan shuttle him to classes in gymnastics, swimming, soccer, cello, and religion.

Losing the familiar anchor of a close-knit community, says WMC sociologist Rees, can leave both adults and children feeling lonely and isolated. "Altruism and mutual dependency are very much on the decline as values," he says. "Children model their parents, and they're not seeing the interdependency among their parents [and neighbors] that they used to see." Rees worries that we may be raising a generation of kids who are self-reliant, but lacking in security.

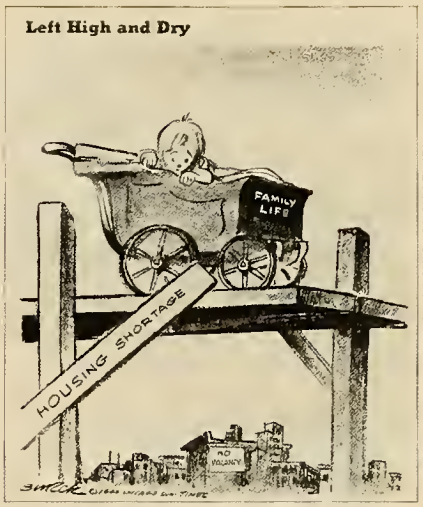
"Neighborhoods used to give individuals a connectedness that they just don't get anymore," he continues. "The people I see in my clinical practice feel like objects out there. Even among high achievers, there's still the underlying sense of not feeling like they belong. They're groping for ways to meet those needs."

Part of the problem may be rooted in the way America's suburbs have been designed, say architects and planners. "Our old patterns of growth are built on isolation—an isolation from the environment, an isolation between activities, and ultimately an isolation between individuals," Sim Van der Ryn and Peter Calthorpe wrote in *Sustainable Communities*. Secluded subdivisions, separated from shopping malls and office parks, have made homeowners prisoners to their cars, the authors argue. At the same time, streets lined with neighborhood stores and sidewalks for pedestrians have virtually been eliminated from subdivision designs.

Van der Ryn and Calthorpe believe that community spirit can be reestablished if suburbs are redesigned to meet the changing needs of Americans. Time- and energy-consuming commutes could be eliminated, they suggest, by building a local employment base into each community—either through localized employment centers or through computer networks that would enable people to work out of their homes.

Dependence on the automobile would further decrease if shopping, daycare, and other everyday services were accessible by foot or public transportation, the authors say. And social interaction among neighbors would increase if homes were built more closely together.

What they and other planners envision is a return to the neighborhoods of yesteryear, in which people could walk to work, the grocery store, the post office, and the library. There is some evidence to show that this could work. Within the last two years, the Miami-based architectural team of Andres Duany and Elizabeth Plater-Zyberk has designed nine such communi-



REPRINTED WITH PERMISSION OF CHICAGO SUN-TIMES

In 1949, many worried that the postwar housing shortage would damage the birth rate and family stability. Forty years later, other constraints are taking a toll on daily life for many families.

"A sense of community doesn't exist where I live today," says Edward Gonsalves (WPI '81), pictured with wife, Paula, and son, Matthew. "I really enjoyed that (when I was growing up) and I miss it."

ties in Texas, Indiana, New Hampshire, New York, Maryland, and Florida.

These neighborhoods don't have the secluded cul-de-sacs that are standard in suburbia. Instead they're laid out in a traditional village grid pattern, with a mixture of homes, offices, and shops fanning out along sidewalks from the town center. This plan means that homeowners have to live closer together, with smaller yards; not unexpectedly, adults in these communities are frequently seen chatting together, while their children play in the front yards.

The neighborliness so intrinsic to village living is what drew Karen Rex back to her hometown of Chatham, New Jersey, after she graduated from WMC in 1987. With its shop-lined Main Street and strong sense of civic pride, Chatham is an authentic prototype of the "new villages" being designed for the future. Says Rex, a sales referral representative for AT&T, "Chatham is your typical hometown. Everybody knows everybody else. I can't go downtown without running into someone I know."

Within the borough's 2.3 square miles lie a variety of large companies, smaller service-oriented businesses, and light industries. The downtown district, lined with dogwoods, is within easy walking distance from Rex's family home. Sixteen hilltop manor houses—built as summer hideaways for New York's millionaires at the turn of the century—sit at Chatham's crown, overlooking the scenic Passaic Valley and sprawling Manhattan skyline.

When she was in high school, Rex says, her friends couldn't wait to escape the "confines" of small-town living. But once they graduated from college, many of them, like herself, chose to return. They feel a certain fondness for events like Fishawack Day, a biennial festival of outdoor music and dancing that stretches into the early hours of the morning.

Rex and two friends are trying to save enough money to move out into an apartment of their own. Since Chatham is just one hour west of New York City, rentals are relatively high: two-bedroom apartments go for at least $800 a month. She could have lived more inexpensively if she had remained in Maryland and rented in a suburban apartment complex. But Rex says she's willing to trade off high rental payments for the stability that Chatham provides in her life.

"The cost of living is just something I'll put up with to stay in this area," she says. "People look at you, and you know they're seeing the little girl they knew way back when. Eventually I want to raise my own family here. I like the sense of belonging that Chatham gives me."

Rex isn't alone in her sentiments. In a recent *USA Today* poll, 39 percent of the people surveyed said they would prefer to live in a small town. The numbers seem to reflect a nostalgic yearning for a simpler time and a simpler place—a return to the Norman Rockwellesque "Front Porch America" that President Bush described in his inaugural address, where crime and pollution don't exist and neighbors know far more about one another than merely their names and addresses.

Reality tempers such idyllic imaginings. Since 1985, more than half a million rural residents have left America's small towns, where business and services are drying up. Foreign suppliers, with their lower wages, have taken jobs away from American manufacturers, many of which were the economic mainstays of their towns. And the '80s deregulation of the rail, truck, bus, and airline industries meant that corporations could abandon services or raise rates in hundreds of small towns. The result? Less than 24 percent of the population now lives in rural areas, compared with 44 percent in 1950, according to the U.S. Census Bureau.

If small towns are being sapped by out-migration, and suburban communities are losing their cohesiveness, how will people—gregarious by nature—cope in the 1990s? Villanova's Copel is optimistic that they will "connect in other places," such as churches or volunteer organizations. "We're in a period of transition," says the family counselor. "Neighborhoods are not the only place to form long-lasting relationships. We'll still get what we need, there'll just be a changing focus."

The Finkelsteins have done just that. Since their move to New York six years ago, Larry and Susan have been active in the local chapter of their WRC alumni association. Larry has found that newcomers to the area are grateful to hook into a network of people who have shared the same college experiences.

But he says his family's closest bonds have been forged at their synagogue. Last December the Finkelsteins went on a weekend retreat with 20 other young families. Since then the group has gotten together once a month to talk about issues pertaining to parenthood and their faith. Says Larry, "As a result of the experience we had over that weekend, a sense of community was formed. That's what we were looking for."

Sue De Pasquale is assistant editor of the Alumni Magazine Consortium.

"Eventually I want to raise my own family here in Chatham," says Rex.

DOUG McDONOUGH

Curiouser and Curiouser

WPI's computer science department has grown up with the computer.
By Virginia L. Woodwell

In 1959, WPI acquired its first computer, an IBM 610—"very, very primitive by today's standards," says Ray Scott. Computing first found its way into the WPI curriculum as part of advanced calculus courses; the first stand-alone computer science course, Scott notes, was a beginning course in the programming language FORTRAN aimed at seniors.

"Computers did not catch on like wildfire here," Scott says, noting that it was students who first adopted the new machines. Faculty members, he says, were forced to follow.

There's a phantasmagoric, Alice-in-Wonderland quality to the arrival of computer science in our culture. At WPI, for example, computer science didn't exist just 30 years ago—not as a department, not as a course, and scarcely as a subject with that name.

Today, it is a firmly established discipline represented by an academic department that will observe its 20th anniversary this year and which, after repeated moves throughout its brief history, will get its own home at the end of the year with the opening of the $9.7 million George F. Fuller Laboratories, a building specifically designed to meet the mushrooming needs that the discipline of computer science itself has helped spawn.

How has all this come about? Not, say those who have been around for more than the twinkling of a CRT, without a few leaps of faith and, here and there, a few glitches.

When it comes to chronicling the history of computer science at any college, it's a measure of the youth of the discipline that the history is still mostly oral. At WPI the unofficial historians are Mary Hardell, who joined the department as one of its first instructors in 1972, and Ramon "Ray" Scott. Scott, who began his WPI career as a member of the mathematics department, has been on the college's faculty since 1957.

"Back then," he recounts, "IBM was trying to persuade schools to get computers, and to start teaching computers, by offering big educational discounts and training faculty. I remember going off for a week to Poughkeepsie where I was 'dined' by IBM (not 'wined,' because, at the time, they didn't allow any liquor). I was in with a large group of other college math professors, and they were trying to convince us that computers had a place in the educational program at colleges."

Scott returned from Poughkeepsie a convert, but he and his fellow computer novices faced some substantial hurdles in their quest to bring computers to WPI, not the least of which was the then formidable cost of computer hardware.

Early on, the cost hurdle was circumvented through time-sharing, Scott says. "IBM put a large computer in at MIT. MIT got one-third of the computer's time, a group of other colleges, including WPI, got one-third use, and IBM got the other third. This stimulated a lot of interest."

In 1959, WPI acquired its first computer, an IBM 610—"very primitive by today's standards," Scott says. Computing first found its way into the WPI curriculum as part of advanced calculus courses; the first stand-alone computer science course, Scott notes, was a beginning course in the programming language FORTRAN aimed at seniors.

Robert Kinicki heads the Computer Science Department.

JANET WOODCOCK

"Computers did not catch on like wildfire here," Scott says, noting that it was students who first adopted the new machines. Faculty members, he says, were forced to follow.

After the 610 was retired in 1965, it was replaced by another, more powerful IBM. Those computers, each in its turn, constituted WPI's first computation center, which was headed by Eliot Buell, head of the WPI math department. They were the only machines on campus through most of the 1960s. WPI eased into an official commitment to computing in 1967 with the opening of the Worcester Area College Computation Center (WACCC), which provided administrative services to WPI and several other area colleges from the basement of the George C. Gordon Library.

In 1968, WPI hired Norman Sondak to head WACCC. Sondak, who had developed pioneering computer applications for Mobil Oil, RCA and the J. Walter Thompson Co. before coming to WPI, was also named WPI's first professor of computer science and charged with developing a computer science curriculum. Accordingly, the Computer Science Department dates its origin to the following July, when that curriculum was implemented.

Scott, who transferred from the math department, and John Sistare were appointed the department's first faculty members. The department enrolled 23 graduate students in 1969. One year later the department opened its doors to undergraduates and the first bachelor's degrees in computer science were awarded in 1972.

Today the department enrolls an average of 40 undergraduates each year. And, in addition to the master's degree, WPI now offers a Ph.D. in computer science—the first doctorate was granted in 1987.

As the department grew, so did the quantity and sophistication of the computing equipment amassed exclusively for the use of its students and faculty. Today the department's hardware ranges from the Digital Equipment Corporation VAX computers in the teaching laboratories, to the sophisticated graphics workstations employed in research. With the newly completed campuswide high-speed data network, the department can link its machines to other computers around campus, around the nation, and around the world.

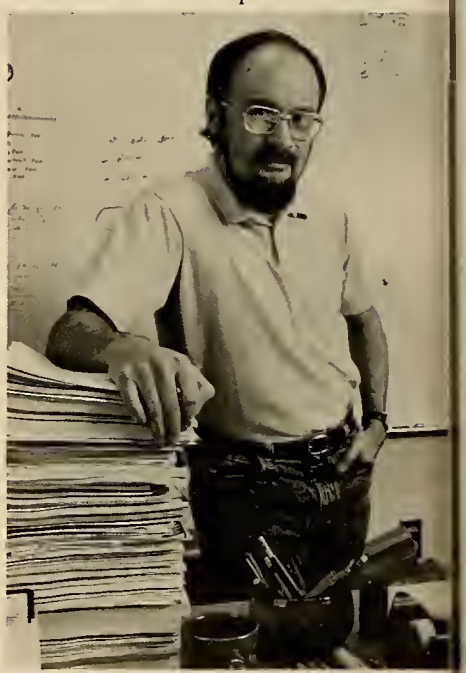
Because of these and other advances, WPI's Computer Science Department in 1986 was among the first group of departments nationwide to be granted accreditation by the Computer Science Accreditation Board.

"We've turned the department around," notes David Brown, who can lay claim to at least part of the credit for raising the department's research profile. "Now we are getting funding, we have people with national reputations, and we are attracting faculty candidates from top schools who go on to do good work."

Moreover, he adds, all this has happened without sacrifice to either the department's high teaching standards or morale. Indeed, Brown and his colleagues assert that the new emphasis on research has sparked renewed enthusiasm for teaching.

Even more significant, perhaps, than the rapid growth of WPI's Computer Science Department is the department's dramatic new commitment to original research. In part, this is a reflection of a renewed emphasis on scholarship Institute-wide. But it is also the product of an infusion of new research-oriented faculty members into the department.

Today department faculty members present the results of their work regularly at scientific meetings and conferences. Department researchers have joined with scholars from other departments to form



AI researcher David Brown.

interdisciplinary research groups in artificial intelligence, vision, and fire protection engineering (computer simulation of shipboard fires). And, faculty are receiving significant funding from government agencies and industry for their work.

"We've turned the department around," notes David C. Brown, who can lay claim to at least part of the credit for raising the department's research profile. "Now we are getting funding, we have people with national reputations, and we are attracting faculty candidates from top schools who go on to do good work."

Moreover, he adds, all this has happened without sacrifice to either the department's high teaching standards or its morale. Indeed, Brown and his colleagues assert that the new emphasis on research has sparked renewed enthusiasm for teaching.

Robert E. Kinicki, who joined the department in 1978 and was named department head last year, concurs. "We were a

completely different department 11 years ago. Today we're becoming a good research department—as good as we can be for our size."

Kinicki's own research invites the broad perspective. His field, like that of his colleague David Finkel, is computer networks. Networks, Kinicki explains, have made possible distributed processing, a way of speeding up problem solving by distributing the pieces of the problem among several computers. Distributed processing also refers to the growing trend away from large mainframe computers and toward interconnected networks of smaller, decentralized computers.

Kinicki says he believes (and he acknowledges a bias in this belief), that "mainframes are dinosaurs. The days of using mainframes to run companies are over. Distributed computing is here." Still, Kinicki contends that distributed computing is "here" today only in part.

"There are some very difficult problems yet to be solved," he says. Among the most important is guaranteeing that when multiple users access the same data (conceivably at the same time), the data are maintained consistently.

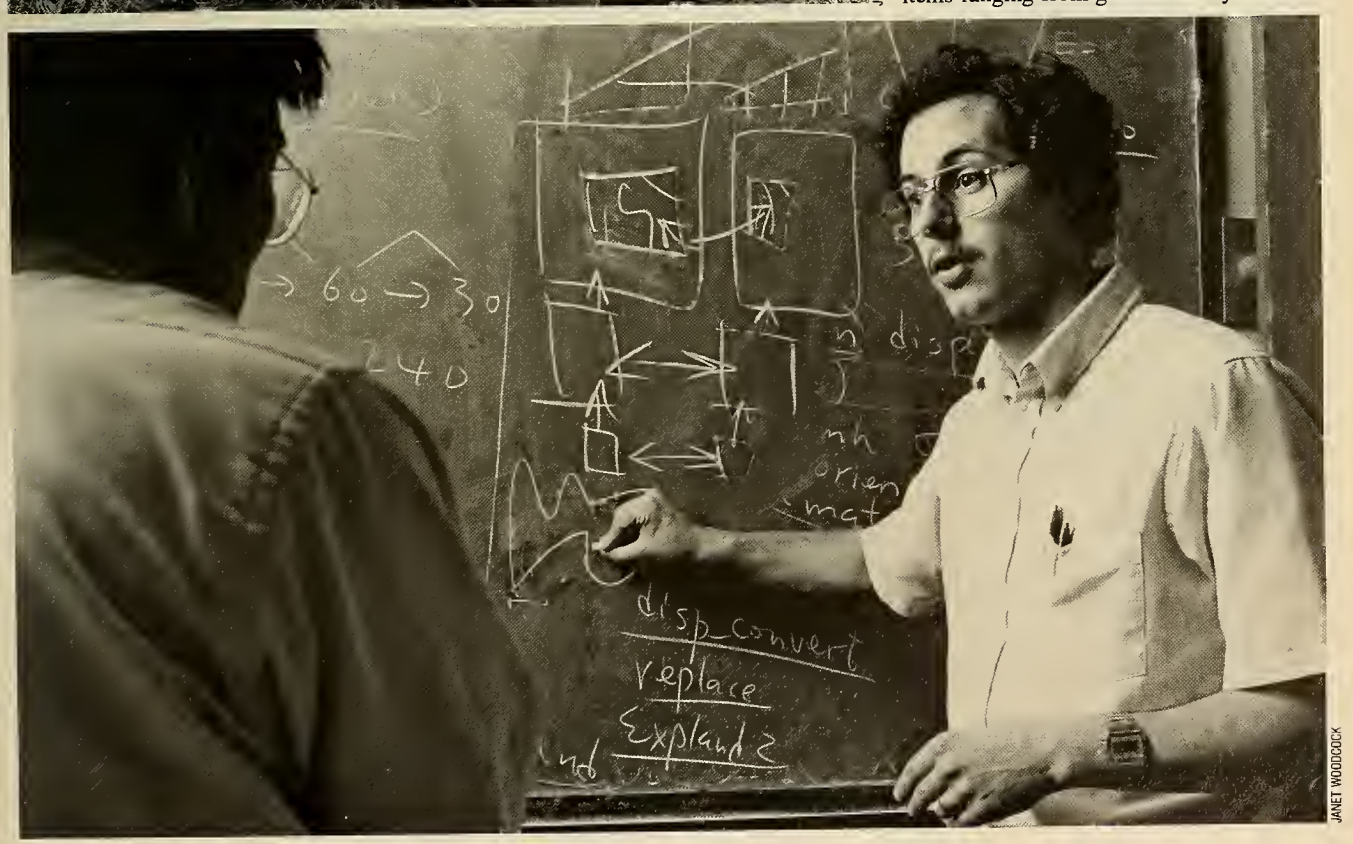
In contrast to Kinicki's work, David Brown's research has a narrow focus. A transplanted Englishman who first came to WPI in 1980, Brown left for two years in 1983 to complete his doctorate at Ohio State University. Since his return, he has been concentrating on research in artificial intelligence (AI). In particular, Brown, with $200,000 in support from the National Science Foundation, is interested in understanding and mimicking with computers a very narrow field of human behavior—the process of design.

Designing something, Brown says, is an enormously complicated task with many facets and stages. To enable a computer to simulate this process, Brown first analyzed the kinds of problems a designer faces and then developed a computer language with which to "write what the designer knows."

Brown uses the language to create programs through which "the computer becomes the designer, performing autonomous routine design on its own." Brown's expert system has been used to design items ranging from gears to air cylinders.

Theoretician Stanley Selkow (top) explores "knowledge trees." Michael Gennert "teases out" the fundamental principles underlying stereo vision.

JANET WOODCOCK



JANET WOODCOCK

As the Computer Science Department begins its 21st year, there is much to look forward to, including the opening of Fuller Laboratories. Still, the nature of the discipline is such that there will be a great deal of work ahead.

The work will stem, as it has in the past, from the continuing rapid growth of this young discipline. With the nature of computing machines and information technology constantly in flux, faculty members are under constant pressure to reassess and update the content of the curriculum, notes Department Head Robert Kinicki.

ROBERT ARNOLD

His most recent interests are "constraints," the issues the designer must take into consideration before proceeding from one decision to another—for example, when considering whether piece "A" will fit into piece "B."

"What I'm trying to do," he says, "is to see if we can make conjectures about the way constraints change over time as a designer becomes more experienced." He says his aim is to write a set of programs that can be attached to a design system. "When the system is run several times, with slightly varying requirements, these little programs, which change the way the constraints operate, will make changes in the design system," he explains.

"Over a period of time, the design system will gradually adjust itself. It will make itself more efficient, and make the process more routine."

It will, in short, behave, in these limited ways, like a human designer.

Brown says his work is "a form of cognitive psychology or applied epistemology." His interest, he stresses, is in "analyzing what people know and how they use what they know." He says he wants his system to "behave in ways an expert would recognize as reasonable behavior."

ROBERT ARNOLD

Computer vision researcher Matthew Ward (top) and database expert Nabil Hachem.

In AI, computer programs designed to be capable of some form of "expert" performance are known as expert systems. The process of extracting the expertise from the original, human experts is known as "knowledge acquisition."

Lee A. Becker is the department's specialist in knowledge acquisition, and he brings to his work an unusual background. Originally a professor of Slavic languages and theoretical linguistics, he first turned to computers after discovering that they were the most efficient way to analyze sound patterns in language. He was and is, he says, "most interested in the way peo-

ple think."

One facet of Becker's current research concerns the automation of knowledge acquisition, the aim being to speed up and ease what can be a time-consuming and laborious process. Becker, with a $171,000 grant from NASA, will also be working with two faculty members from the electrical engineering department to find ways to verify expert systems—in other words, to assure that they work as they are supposed to.

Since coming to WPI five years ago, Becker has also become increasingly interested in finding applications for expert systems in manufacturing. For the past four years, through WPI's Management of Advanced Automation Technology (MAAT) program, he has been working on such applications for Worcester's Wyman Gordon Company.

Michael A. Gennert came to WPI's computer science department in the fall of 1987 directly from MIT, where he had earned bachelor's, master's and doctoral degrees. Matthew O. Ward, himself a 1977 WPI graduate (he earned his master's and Ph.D. degrees from the University of Connecticut) returned to WPI as a faculty member three years ago, following six years in industry. Gennert and Ward are interested in vision, though from quite different angles.

Gennert, whose approach tends toward the theoretical, says his work is aimed at unearthing some "very deep principles" underlying vision, particularly stereo vision and stereo imagery. Such principles, he explains, could be likened to those, like lift and drag, which explain how birds fly.

Just as humans were unable to design aircraft until they understood those principles, so it may be that they will be unable to fully understand—or to duplicate—the very complex process of vision until they, as he puts it, "tease out" the theory behind the mechanics.

"My research interests are more in the applied end of things," says Ward. With $60,000 from the National Science Foundation, he is experimenting with image segmentation, which involves taking the thousands of individual light or dark points that constitute a video image and clustering them into sets that correspond to, say, surfaces or objects.

The goal of this process is to reduce the image to its essence—that combination of shapes, contours, edges or intensities that still provides enough information to identify the object. Processing the image in this way may, for example, help a robot pinpoint a desired object on a cluttered assembly line.

This technique of reducing an image also makes it easier and faster to manipulate with a computer. "It's much easier to work on 100 segments of an image than a quarter of a million," Ward notes.

Every environment, Ward says, contains certain features (for example, color, texture, size, reflectivity or smoothness) that can be expected to remain relatively constant over time. From the point of view of a vision system, these features (constraints, in the parlance of image processing) place limitations on the visual characteristics of objects within those environments. Through his research, Ward is looking for ways to exploit knowledge about these constraints to make the segmentation process more efficient.

Nabil Hachem joined the faculty last fall, fresh from completing his doctorate at Syracuse University. His interests are very large data and knowledge bases. He is alone among the department faculty in that focus, and his research at WPI is just now getting under way, but he perceives some potential for interaction with other department researchers.

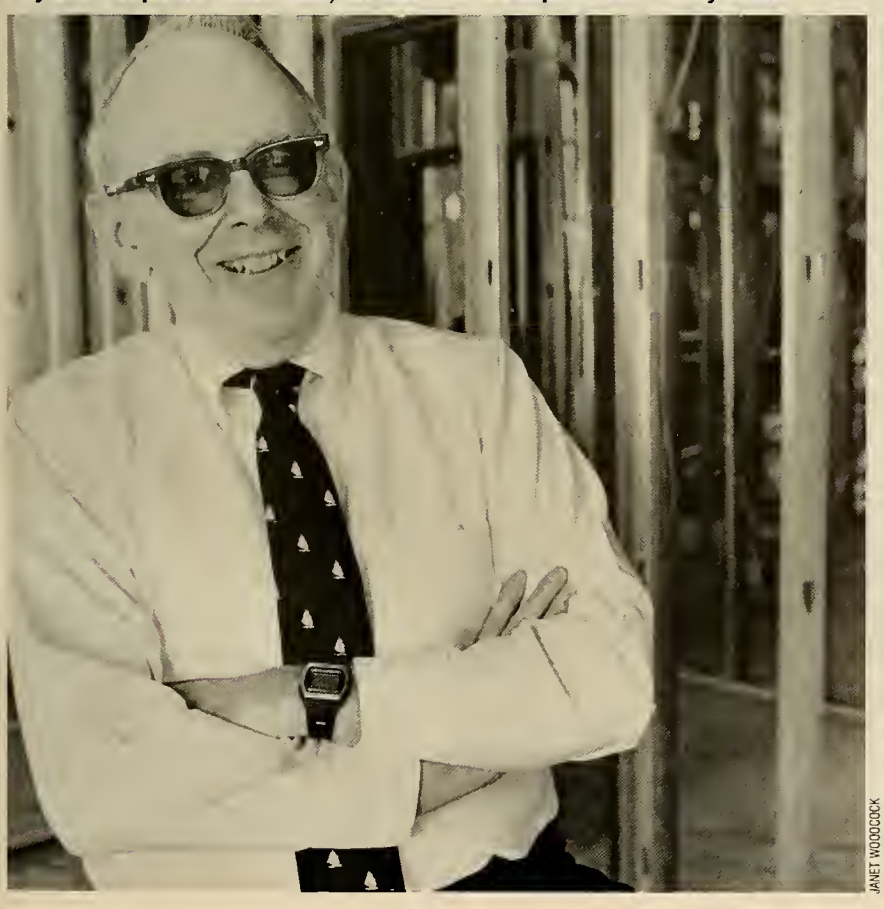
Like Hachem, Karen Lemone, who is spending the current year on sabbatical in Switzerland, is interested in the management and manipulation of data, though the data that intrigue her are words. An expert on computer languages and compilers (programs that convert higher level languages to instructions a computer can perform), she has recently begun to apply her work to the field of automatic document processing or electronic publishing.

"When Gutenberg invented the printing press, book production became more cost effective," she says. "Today we are trying to use computers to facilitate document preparation. For computer scientists who are interested in language, the field combines the best of both worlds. There are abstract technical issues to address—for example, what is a document from a structural point of view?—along with real, down-to-earth applications."

Stanley M. Selkow, another of the department's active researchers, also serves as a kind of department gadfly. Regularly, he says, he asks both himself and his students, "What is your responsibility for what you are doing, and what will be done with the tools you're developing?"

The only member of the department to

Ray Scott explores Fuller Labs, the latest of the department's many homes.



JANET WOODCOCK

hold the rank of full professor, Selkow, a self-described "hippie from the '60s," says he will not do applied research and will not accept what he terms "military funding." Because he believes that "computer science is a science, not an engineering discipline," he argues strongly that computer science students should receive broad-based educations.

For the same reasons, he heartily welcomes the department's new emphasis on research, in part, he says, because of its impact on teaching. "It's really hard to keep up exciting teaching if there's not enough scholarly activity," he notes.

Selkow's own work in computer theory concerns complexity. He is, he says, working through such questions as: "What does it mean to say that a problem is complex? What does it mean to say that there is not a good solution to the problem?"

It is useful, he maintains, to know when and if good solutions to problems don't exist. "Negative results are just as important as positive, in a certain sense. They are just a lot harder to establish."

As the Computer Science Department begins its 21st year, Selkow and his colleagues agree that there is much to look forward to, including the opening of Fuller Laboratories. Still, the nature of the discipline is such that there will be a great deal of work ahead.

The work will stem, as it has in the past, from the continuing rapid growth of this young discipline. With the nature of computing machines and information technology constantly in flux, faculty members are under constant pressure to reassess and update the content of the curriculum. Says Kinicki, "I'm currently teaching a course in computer networks, which was not even a discipline when I was in school 11 years ago."

"I'm more or less managing to keep up with people who are doing work in AI in design; I cannot keep up with people who are doing work using AI in engineering and manufacturing," notes David Brown. "I cannot keep up with AI in general; and there's no way I can keep up with 'Computer Science.' It's just impossible."

The same growth makes costly equipment quickly obsolete, and Kinicki sees one of the major challenges facing the department over the next five years as acquiring equipment that is both up-to-date and appropriate to the changing needs of the department's new faculty.

Moreover, say faculty members, proper responses to these issues are imperative if the department is to continue to attract good students in the face of a declining pool of college-age students and dwindling interest in the sciences and engineering.

Matthew Ward, who values his own undergraduate training in computer science at WPI, urges aggressive recruiting to convince prospective students and their teachers that "computer science is exciting—that it is something other than programming."

In fact, computer science enjoys an important advantage over other disciplines. "Being a young discipline, we are not so set in our ways," Kinicki notes, "so it's easier to experiment. And we are experimenting a lot."

The field of computer science also enjoys a unique position in relation to business and industry. It was, in a sense, created by industry; now, the child grown big, it is sometimes industry's judge and arbiter.

Says Kinicki: "We at WPI live and work in the midst of dozens of high-technology vendors. They're good people, they're qualified people. But they're driven by getting their product to market. Sometimes we, as scientists who evaluate the products, become umpires between different vendors, trying to argue for the best product—the best functional product.

"In the computer industry, very often having the best product isn't most important; sometimes having the first product is most important."

Aware that vendors are now racing to bring the first distributed system to market, Kinicki suspects that "the first one is not going to be the best, though it may have a tremendous impact." And that will be bad, he says, because products that are first can outlast their welcome.

"FORTRAN was introduced in the 1950s," Kinicki notes. "It was a great tool then, but now everybody says that FORTRAN is bad. It may take 40 years to get rid of FORTRAN, because it's firmly in place."

That conflict between getting there first and getting there best, Kinicki says, recurs constantly in computer science—even in college computer science departments.

"For the faculty at WPI," he says, "the challenge in the years ahead is to do both."

Woodwell is a freelance writer based in East Douglas, Mass.

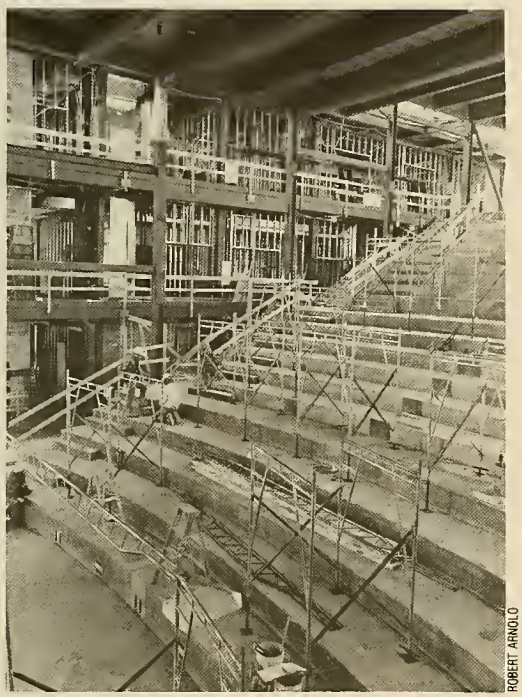
Lee Becker works to endow computers with the knowledge of human experts.

ROBERT ARNOLD

Computer Architecture

WPI builds a state-of-the-art home for the information sciences

By Shirley Standring


ROBERT ARNOLD

Like the high-technology equipment it will house, WPI's newest academic building is an elegant combination of form and function, of beauty and utility. Rising gracefully from a hillside on the northeast corner of the WPI campus, it stands as a symbol of the college's commitment to provide its students and faculty with the state of the art in information technology.

When it is completed later this year, the George F. Fuller Laboratories, named in honor of the Worcester industrialist and longtime WPI trustee, will house the college's computer science department, centralized computer hardware, computer support staffs and the Instructional Media Center (the Institute's audio-visual support center).

Fuller Labs, the first new academic building constructed at WPI since 1966, will also have a 400-seat lecture hall, the campus's largest. The steeply sloped lecture hall will be equipped with sophisticated projection equipment for 70-millimeter films,

Fuller Lab's 400-seat lecture hall takes shape (right). A translucent skylight will brighten the building's interior (Atwater Kent Laboratories is seen at left).

ROBERT ARNOLD

ROBERT ARNOLD

ROBERT ARNOLD

A central spine (right) links Fuller's five floors. The building is scheduled to be completed early next year.

slides and computer video images.

The five floors, including two subfloors, of the $9.7 million building angle down a triangular hillside bordered by Kaven Hall, the Gordon Library and Atwater Kent Laboratories. The site was recommended in a campus master plan prepared in 1982 by Earl Flansburgh and Associates, a Boston architectural firm, according to John E. Miller, vice president for physical plant.

A steel-frame building with red brick facing, Fuller is adorned with an unusual translucent fiber glass skylight that runs the length of the building, giving the interior a sense of airy brightness. Beneath the skylight is a central corridor and a descending staircase that passes through all of the building's levels and opens to the lecture hall at four levels, Miller says.

This central spine begins at the building's stately entrance between Atwater Kent Laboratories and the Gordon Library and terminates at its northeast end in an entrance to a plaza that will join Fuller and Kaven Hall. The spine also links the building's three components—a lab wing, an office wing and the lecture hall.

It is appropriate that Fuller will house state-of-the-art equipment, for the building itself is a showcase of modern technology, Miller notes. A digital energy management system with a central computer station will control the environment. Because computers are extremely sensitive to heat and humidity, it will be the only fully air-conditioned academic building on campus.

Each laboratory will have its own power distribution for both room power and "clean" power—special electrical service designated for computers. Two separate systems will supply power to the building, both originating from a 2,000-KVA substation, the largest on campus.

The interior of Fuller Labs will feature a mixture of finished and unfinished concrete masonry and gypsum board walls; and tiled, carpeted and bluestone floors. Slightly tinted thermal pane windows will reduce energy costs, Miller says.

"Fuller Labs and the equipment in it will make our students better prepared to meet the world in which they will work," says Robert E. Kinicki, head of WPI's Computer Science Department. Noting that the department, in 1986, was among the first in the country to receive accreditation from the Computer Science Accreditation Board, Kinicki points to a five-inch-thick binder in his bookcase.

"That was our accreditation application," he says. "The board looked at everything—our equipment, our curriculum and our faculty. Our one weakness was our limited space. When we are reevaluated, the new building should eliminate that concern."

WPI's computer activities are now housed in five buildings and are spread across the campus. Computer science courses are taught in two buildings. "It is difficult to manage a department in which the activity is so divided," Kinicki says.

He says the role of the Computer Science Department itself is divided between providing a service to the college's engineering and science students and offering more intense instruction for electrical engineering and computer science majors.

"The biggest change in the engineering field in the last few decades has been the introduction of the computer as a tool for the engineer," Kinicki says. Today nearly every graduating engineer and scientist is expected to have some computer science skills, he notes.

One of the best environments for learning about computers, Kinicki says, is the laboratory, where human and machine meet one-on-one. It is in the lab that students begin to understand and explore the great potential of the computer. Appropriately, laboratories will form the heart of the Computer Science Department's space inside Fuller Laboratories.

"Some of the labs are designed for teaching, others for research," Kinicki says, "though the building's design will enable us to make adjustments as our emphasis shifts."

Kinicki notes that some colleges place a priority on research, reserving most of the time on their computers for faculty and graduate students. At WPI, students are the highest priority, he says, so Fuller's labs will accommodate research, project work and classwork equally well.

"The construction of Fuller Laboratories comes at the tail end of a lot of changes at WPI," says David Cyganski, vice president of information systems and services. "It will bring together in one location all of the heaviest users of computing services, and all of the services related to capturing and distributing information."

Humans tend to group and designate eras by the advances that are made during them. We've lived through the atomic age, the space age, and now, Cyganski says, we are living in the information age.

"The technological advances are greatest right now in the area of information services," he says. By information services, Cyganski means the management and use of information—information that is accurate and up-to-date. He says WPI's new state-of-the-art campus voice and high-speed data network will make it easier than ever before to provide information services to all members of the WPI community.

In addition to serving as host to the college's information technology, Fuller Laboratories will provide an inspiring environment for education. Like Kinicki, Cyganski says he expects that all WPI students will have reason to utilize Fuller Labs and its services.

"We have tried to emulate what our graduates will find in industry," he notes. "Everything today, on campuses and in the work environment, is computer-related. For example, in chemistry and chemical engineering, the computer is a big help in determining molecular design. It is possible for a student or professor to see what the result will be when two agents are combined at a given temperature.

"You don't have to build things anymore, whether molecules or buildings, to see how they will look or act. All you have to do is describe it to the computer and it will tell you. Even to someone like myself who works with computers all the time, it can almost seem like science fiction."

While Fuller will help provide students with a state-of-the-art education today, it will also give the college an edge in making sure its computer facilities remain state of the art in the years to come, Cyganski adds. "Industry is only a little behind us now, and we have to maintain that margin in order to benefit our students. Now we can approach companies and ask for gifts of equipment because we have a modern building in which to showcase it."

"What Fuller Laboratories does is take our state-of-the-art services and make them visible," Cyganski adds. "It is symbolic of the fact that we are dedicated to being a leader in the area of technological education. With the addition of Fuller Labs, we can now say confidently that our facilities, our networking system and our physical plant are as good as you'll find anywhere."

Standring is a freelance writer who lives in Spencer, Mass.

Salisbury Scholars Take a Non-traditional Approach

As competition for quality undergraduates increases, older students are proving to be an important untapped resource

One, an editor for a local newspaper, indulges his interest in physics by studying for an undergraduate degree at WPI while he works at night.

Another pursues an interest in biomedical engineering developed during years as a professional ice skater.

Still another, a longtime employee of a printing firm, returns to WPI to complete work on an electrical engineering degree begun in 1968.

And yet another, a former fireman, works towards a degree in fire protection engineering, a goal kindled after he suffered a disabling injury on the job.

They are all non-traditional students, so-named because they have chosen to work toward undergraduate degrees after the age of 25, a time in life when most undergraduates have earned their diplomas and gone on to careers or graduate school. But they have more in common than age; nearly all arrived at WPI by different routes and for different reasons than most of their younger classmates.

Some "stopped out" of their undergraduate careers and are now ready to tie up this loose end in their lives, notes Ann Garvin, director of academic advising. Others put their education on hold to begin work or start families. And some are finding that, with the information explosion, they need more education to keep up in their careers.

"Some already have degrees in other fields—even master's degrees," Garvin says. "For whatever reason, they have decided to pursue studies in engineering or science at this point in their lives."

Recognizing that these older students often have special requirements, concerns and constraints on their time that separate them from traditional students—things like mortgage payments and day care—WPI recently established a new program called the Salisbury Scholars to help this growing segment of the student population succeed.

"We've done little so far to attract these students to our campus," Garvin notes. "They have come to us on their own, by and large. But as competition for quality undergraduates increases, older students will likely prove to be an important untapped resource. It would be unfair for us to go out and recruit these students if we have nothing to offer them—if we are totally geared to 18-year-olds."

WPI brought its first 65 Salisbury Scholars together this winter for a luncheon at the home of Acting Provost Donald N. Zwiep. Garvin said most were surprised to meet other undergraduates their own age.

"Many think they are the only older students on campus," notes Garvin, who was herself a non-traditional student, completing her undergraduate degree after her children were in school. "They also tend to be lonely and feel isolated from the WPI community."

But loneliness is not their only concern, Garvin notes. "They worry about housing. Many commute long distances to attend classes because they cannot afford to move or don't want to uproot their families; others choose to move and then have to face the realities of our housing market.

"They also worry about their ability to keep up academically and to juggle work, family and school. And, they're concerned about their ability to pay for their education—they want to make sure they get their money's worth."

To address these and other concerns, the Academic Advising Office, the Dean of Students Office and the Admissions Office have teamed up to help smooth the way for the college's Salisbury Scholars. Since the majority of non-traditional students transfer to WPI from other colleges (in fact, about 50 percent of all transfer students are over age 25), Roy A. Seaberg Jr., director of special admissions, sees many during their initial contact with the college.

As part of the Salisbury Scholars program, Seaberg makes sure they are academically prepared for a WPI education and helps them sign up for refresher courses—often in mathematics—should they need them. Seaberg also helps address their financial aid needs, which are often very complex.

"Many of these students are married and have families," Garvin says. "They often have unrealistic expectations about their ability to work part time while going to school."

After enrollment, the focus turns to academic advising. Garvin herself spends time with the Salisbury Scholars during their first few terms to help orient them to the college and to sort out any transfer credits they may bring with them.

Within each department, faculty advisors who specialize in working with transfer students help the Salisbury Scholars lay out their academic schedules. Project work often proves to be a particular challenge for older students who transfer to WPI. Since most start out their WPI careers as juniors, they must get a quick start on their required projects to avoid falling behind.

Once students have settled into their academic routines, the final step in their acclimation to WPI falls to the Dean of Students Office. Tom Hartvig Thomsen, assistant dean of students, has worked closely with WPI's international students and understands the social isolation that students who find themselves in the minority can experience. He helps the Salisbury Scholars meet each other and take advantage of such student services as cooperative education and the student counseling center.

While much of the Salisbury Scholars program focuses on the special needs of older undergraduates, Garvin says the program was also created to recognize the unique contributions they make to the college. Most important, she says, they serve as valuable role models for younger undergraduates.

"The faculty who have had them in class say they are excellent students who have well-defined career goals. They bring a spirit of excitement to the classroom because they have often been out there working in the real world. It's not surprising that other students seek them out for help and advice."

—Michael Dorsey

MEMORY BANK

A Life Rich in Firsts

The top scholar in WPI's first graduating class, Henry Armsby went on to become the world's foremost authority on animal nutrition

WPI awarded its first honorary degree nearly 70 years ago at its 50th Commencement in 1921. This honor went to Henry Prentiss Armsby, who had been the top scholar in WPI's first graduating class in 1871.

Armsby was eminently qualified for his alma mater's first honorary Doctor of Science degree. In 1921, he was regarded by many as the world's foremost authority on animal nutrition.

He was only 15, the youngest in his class, when he enrolled at the Worcester County Free Institute of Industrial Science in 1868. This brilliant chemistry major soon earned the nickname of "Professor." Four years later, he ranked first academically among his graduating class, with an average grade of 91.5.

After graduation, Armsby was hired by WPI Professor Charles O. Thompson to be an assistant teacher of chemistry, becoming the first of many alumni to serve on the WPI faculty. In 1872, Armsby enrolled in the Sheffield School at Yale to begin graduate studies that eventually earned him a Ph.D.

Armsby became a scientific pioneer in the relatively unexplored field of animal nutrition. His first book, *A Manual of Cattle Feeding: A Treatise on the Laws of Animal Nutrition,* was the first such work in English. This publication, based on his own research, marked the beginning of the systematic study of animal nutrition in the United States.

Armsby helped establish the Connecticut Experimental Station in New Haven, the first such facility in the nation, and became its staff scientist. By 1880, he had established such a reputation that he was offered a post at an agricultural station in South Africa, a position he declined fearing he might be forgotten in professional circles at home.

When Connecticut established the Storrs Agricultural School in 1881 (now the site of the University of Connecticut), Armsby was appointed vice principal and professor of agricultural chemistry. The following year he was invited by his former mentor

to give the Commencement address at WPI. It must have been a moving experience for both men, since this was the last graduation over which Professor Thompson presided before leaving Worcester to become the first president of Rose Polytechnic Institute in Indiana.

Armsby left Storrs in 1883 to serve as associate director of the new agricultural experimental station at the University of Wisconsin. Here he was instrumental in developing tables of feeding standards based on scientific methods of measuring nutritional value.

In 1887, he was invited to organize and direct an agricultural experimental station at Pennsylvania State University, then a small, struggling school with one building and 68 undergraduate students. In the next two decades at Penn State, Armsby built his international reputation. His most significant contribution was his role in the 1902 development of the respiration calorimeter for use with large animals.

His research with the calorimeter disclosed the economic loss inherent in feeding farm animals agricultural products that could be used directly as human food. His book, *Principles of Animal Nutrition,* published in 1902, became a classic reference for both agricultural researchers and working farmers.

Armsby served a term as president of the Society for the Promotion of Agricultural Science and later a term as president of the American Society of Animal Production. He was elected a fellow of the American Association for the Advancement of Science. Other honors included membership on the Commission on Agricultural Research, election to the Royal Society of Arts of Great Britain and honorary membership in the Royal Agricultural Academy of Sweden.

Armsby made significant contributions throughout the remainder of his active life. Following service on the Inter-Allied Scientific Food Commission headed by Herbert Hoover, he was elected a member of the National Academy of Science in 1920.

Throughout his life, Armsby also retained a lively interest in his alma mater. He was one of the original three vice presidents of the WPI Alumni Association. In a letter to his class secretary, he once noted that the Class of 1871 "had made, at least, a respectable record in the world."

In fact, of all the honors he received, to be selected the first recipient of an honorary degree from WPI must have been an especially moving experience. Although he was 68 years old, he noted at the time that he was planning for "the greatest nutrition research ever undertaken." He was not to carry out this endeavor, though. He died of a cerebral hemorrhage less than six months after the Commencement ceremony.

(The writer is indebted to Donald E. Johnson and James E. Mooney, the authors of *Pioneer Class: Sketches of the Lives of All Members of the Class of 1871 of Worcester Polytechnic Institute,* from which information for this article was drawn. This book, available in the Gordon Library, was published in 1966 as a WPI centennial year project.)

—Roger N. Perry Jr. '45

Perry is editor of Quest, *a periodical reporting on the* Campaign for Excellence.

FINAL WORD

Putting New Life in the Old Mill

Connecticut artists have a picturesque setting in which to pursue their crafts, thanks to Tom Buccino '77

Tom Buccino '77 is giving the term "absentee landlord" a good name. Buccino, a full-time engineer and a part-time photographer who lives in upstate New York, has transformed his family's mill in South Willington, Conn. into an artist's dream.

Buccino's father, Thomas Sr., ran a tool and die company in the three-building complex he had purchased in 1962. The mill, which had stood idle since 1955, had long served the town of South Willington as the Gardner-Hall Thread Mill. After his father decided to close up shop in 1980, Tom leased the mill through 1987 and was in the process of selling it, when he decided he would like to find a way to keep it in the family.

At first, he considered renting it to commercial and industrial tenants, but it became apparent early on that the complex might be better suited to a use unlike anything the building had seen in its 130-year history.

"The view from the mill is suitable for framing," says Buccino, who, when not at work as a mechanical engineering supervisor for General Electric Company in Hudson Falls, N.Y., takes studio and environmental portrait photographs for his business, Latent Image, in Glens Falls. He lives there with his wife, Mary, and two-year-old son, Michael.

So, before the first nail was driven, Buccino sought the advice of several artists on the design for the conversion of the old mill. The result of this unusual landlord-tenant collaboration is The Mill Works, a complex of sun-washed studios overlooking a waterfall and picturesque Hall's Pond.

When prospective tenants tour the buildings today, Buccino says, the consensus is that the idyllic setting is perfect for their needs.

In the first phases of the reconstruction, Buccino divided 7,000 square feet of mill space into bright studios with banks of eight-by-twelve-foot windows to bring the outdoors inside.

In a story about the renovation in the *Hartford Courant,* Susan Wadsworth, an art instructor at the University of Connecticut, notes that it was Buccino's unusual style as a potential landlord that got the project off the ground. "We'd sometimes trade ideas over tea," she told the *Courant.* "The magical quality of Tom Buccino is his flexibility. He even gave us T-shirts with 'The Mill Works' written on them."

"Currently," Buccino says, "we have two sculptors, four painters, two photographers and a graphic artist in the mill. We have the potential to renovate more than 30,000 square feet of studio, gallery, practice room and workshop space for serious artists, musicians and professional art-related organizations."

Late last fall, the second-floor renovations were completed. Says Buccino, "A fraternity brother, Herbie Holmes '78, framed most of the walls for the studios. He and his father and brother own Holmes Construction in Winchendon, Mass."

Looking to the future, Buccino says he would like to devote as much space to the arts as possible. "Our goal is to develop a general art center at The Mill Works. We plan to include not only studio-workshop spaces and rehearsal areas for musicians, but a supporting gallery that would display, and possibly sell, art produced by our tenants and other New England artists and craftsmen."

Buccino told the *Courant* that his enjoyment of photography spurred his interest in the arts. "I have a real interest in the visual. And I knew I'd get more than mere monetary satisfaction in owning art-related space."

Buccino says he doesn't consider himself a landlord, but a photographer who wants to have a studio in the mill himself. "That is why the tenants and I worked hard as a team, with compromises on both sides."

And, there were necessary compromises. While Buccino decided it would not be economical to convert the third floor of the mill, even though the view from that level is extraordinary (uncertainty about whether he could find enough tenants to

Tom Buccino took an empty mill and built an artist's paradise.

fill the space and the cost of heating the area were concerns), he did decide to relocate bathrooms so windows could be used for studio spaces.

While other mill buildings in Connecticut have been converted for use by artists, Buccino's is the first collaboration between artists and a mill owner, says Gary M. Young, executive director of the Connecticut Arts Commission.

"In this instance," he says, "there happened to be a creative landlord with a picture in his mind of what to do with the space."

Filling up the cavernous old mill is a slow process, but Buccino is encouraged by the enthusiastic initial response. For example, in September the Greater Mansfield, Conn., Council on the Arts moved in.

The Mill Works conversion was no spur-of-the-moment project for Buccino. "Doing something about the family mill was on my mind even before I enrolled at WPI," he says.

Somewhere down the road, Buccino says he envisions residency programs, classes, seminars and workshops taking place at The Mill Works.

"We're centrally located and easily accessible to a number of colleges in Connecticut and Massachusetts," he notes.

—Ruth Trask

RICK HARLFORD, HARTFORD COURANT

EXCELLENCE IS...

Building The Endowment for Financial Aid

WPI was the dream of one man, John Boynton of Templeton, Massachusetts. A successful entrepreneur, he believed that a better form of education could equip young men to participate more fully in the new economic order emerging from the ravages of the Civil War.

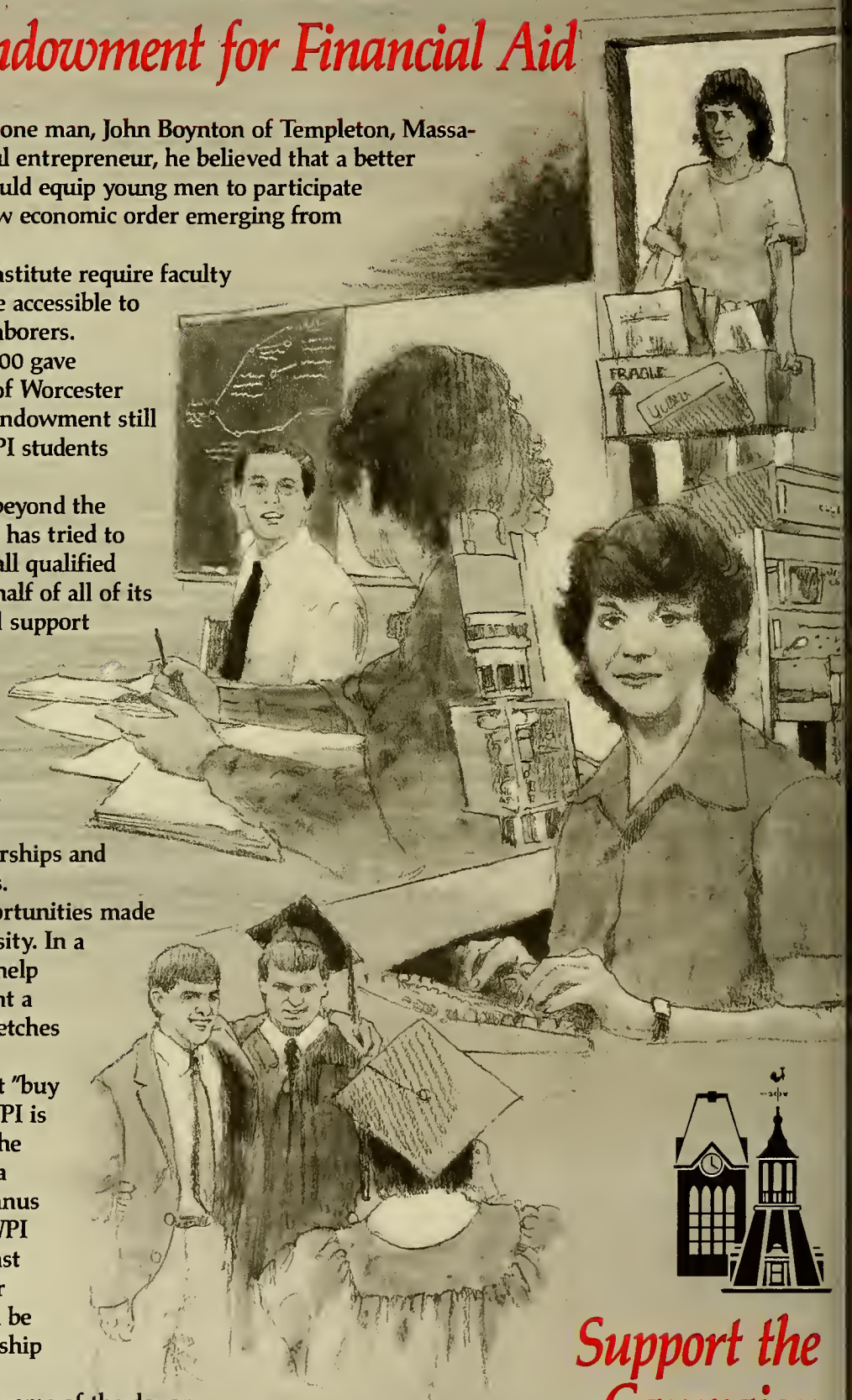
Not only would Boynton's Institute require faculty and facilities, it would need to be accessible to the young sons of farmers and laborers. Boynton's endowment of $100,000 gave tuition-free access to the youth of Worcester County. The income from that endowment still helps provide financial aid to WPI students today.

While WPI has grown well beyond the dream of its founder, the college has tried to maintain "open, free access" for all qualified students. To this end, well over half of all of its graduates have received financial support from the college. This year's graduates received more than $9 million in aid during their years here. Of this amount, well over a quarter was derived from the generosity of hundreds of alumni and friends who have provided endowments for scholarships and other forms of aid over the years.

Many alumni recall the opportunities made available to them by this generosity. In a very real sense, the dollars that help educate today's students represent a tradition of stewardship that stretches back many generations.

But many more alumni must "buy into" John Boynton's dream if WPI is to sustain its great heritage. In the months ahead, WPI will launch a major effort to reach every alumnus and alumna who was aided by WPI support. The goal is to add at least $1 million to the endowment for financial aid. Funds received will be added to a new "Alumni Scholarship Endowment." Individual gifts of $25,000 or greater will bear the name of the donor, or those whose memory is being honored.

There is no greater gift than the gift of opportunity. By helping to keep WPI open to all qualified students, you can make an immeasurable contribution to the future.



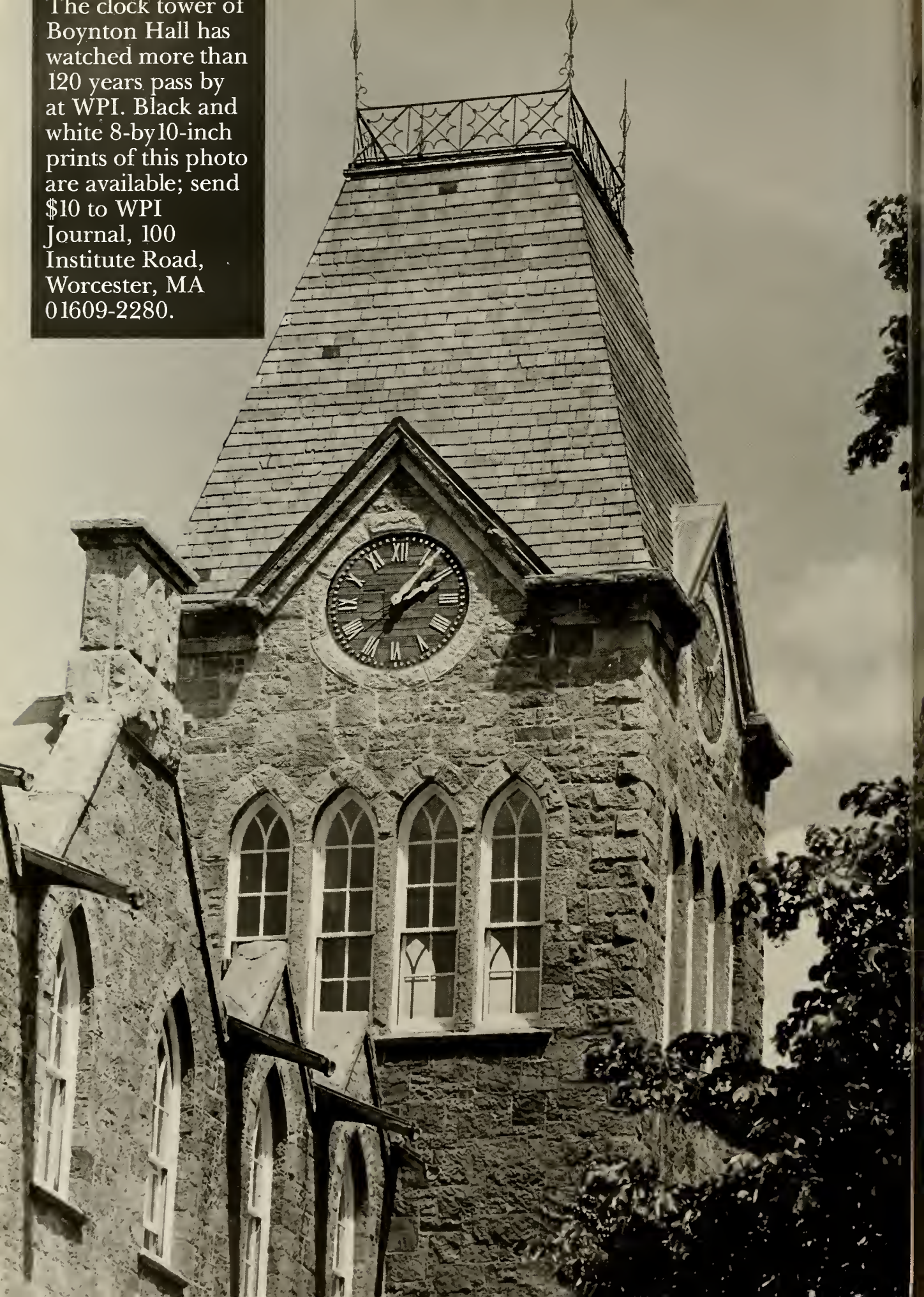
Support the Campaign for Excellence

WPI Journal

RCESTER POLYTECHNIC INSTITUTE

SUMMER 1989

sky Business
the Planets
d Beyond



The clock tower of Boynton Hall has watched more than 120 years pass by at WPI. Black and white 8-by10-inch prints of this photo are available; send $10 to WPI Journal, 100 Institute Road, Worcester, MA 01609-2280.

WPI JOURNAL

CONTENTS

VOLUME XCII NO. 3
SUMMER 1989

Staff of the WPI Journal: Editor, Michael W. Dorsey • Alumni Information Editor, Ruth S. Trask.

Alumni Publications Committee: Samuel Mencow '37, chairman • Paul J. Cleary '71 • James S. Demetry '58 • Judith Donahue, SIM '82 • William J. Firla, Jr. '60 • Maureen Sexton Horgan '83 • Carl A. Keyser '39 • Robert C. Labonté '54 • Roger N. Perry Jr. '45.

The WPI Journal (ISSN 0148-6128 is published quarterly for the WPI Alumni Association by Worcester Polytechnic Institute in cooperation with the Alumni Magazine Consortium, with editorial offices at the Johns Hopkins University, Baltimore, MD 21218. Pages I-XVI are published for the Alumni Magazine Consortium [Johns Hopkins University, Villanova University, Western Maryland College, Western Reserve College (Case Western Reserve University), and Worcester Polytechnic Institute] and appear in the respective alumni magazines of those institutions. Second class postage paid at Worcester, MA, and additional mailing offices. Pages 1-12, 29-40 © 1989, Worcester Polytechnic Institute. Pages I-XVI © 1989, Johns Hopkins University.

Staff of the Alumni Magazine Consortium: Editor, Donna Shoemaker • Assistant Editor, Sue De Pasquale • Consulting Editor, Alan Sea • Contributing Wrap Designers, Cecily Roberts and Royce Faddis • Core Designer, Allen Carroll.

Advisory Board of the Alumni Magazine Consortium: Johns Hopkins University, Ross Jones and Alan Sea • Villanova University, Eugene J. Ruane and D.M. Howe • Western Maryland College, Joyce Muller and Sherri Kimmel Diegel • Western Reserve College, Victoria Anderson • Worcester Polytechnic Institute, Michael Dorsey.

Acknowledgments: Typesetting, Johns Hopkins University; Printing, American Press Inc.

Diverse views on subjects of public interest are presented in the magazine. These views do not necessarily reflect the opinions of the editors or official policies of WPI. Address correspondence to the Editor, The WPI Journal, Worcester, MA 01609-2280. Telephone (508) 831-5609. Postmaster: If undeliverable, please send form 3579 to the address above. Do not return publication.

4 **A World Out of Balance** *Amy Zuckerman*
Engineers and scientists lament a world where people want their technology risk-free.

11 **The Entrepreneurial Spirit** *H. Davis Bushnell*
Richard Abrams '70 confronts a clear and present danger.

I **Danger Below** *Lisa Hooker*
What happens when toxic wastes foul the water we drink? A small town in Ohio found out the hard way.

X **Odes to the '80s**
The witty winners of our limerick contest for readers.

29 **Message in an Empty Bottle** *Paul Susca*
It took 13 years, but Robert Plumb cracked the riddle of the sands of Mars.

35 **Probing the Mysteries of Venus** *Ruth Trask*
Scott Mathews '82 helps design a probe that will map Earth's sister planet.

DEPARTMENTS

2 **Advance Word:** Of pulsars and tuna fish. *Michael Dorsey*

37 **Innovations:** Biology gets new life. *Michael Dorsey*

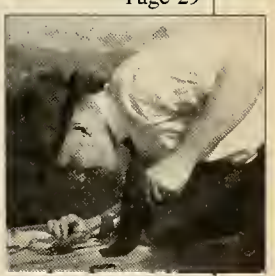
38 **Explorations:** Asparagus, ethylene, anencephalic infants and water in the desert. *Bonnie Gelbwasser*

40 **Final Word:** 80 years of hamming it up. *Roger N. Perry Jr. '45*

Page 4

Page I

Page 29


Page 40

Cover: Richard L.P. Custer, associate director of the Center for Firesafety Studies, knows well the risks we face. Story on page 4. Photo by Patrick O'Connor.

ADVANCE WORD

Of Pulsars, Tuna Fish and the Future of Mankind

Like all astronomers, Valentin Boriakoff is both fascinated with the strange, mysterious objects that populate the universe, and obsessed with learning how they were created and how they work. But for Boriakoff, associate professor of electrical engineering at WPI, the drive to explore the heavens has special meaning.

"The onset of ice ages can happen in as little as 100 years," he says. "The next one can begin at any time, and when it does, conditions on Earth will be very tough. Even if we survive the ice age, the Sun will eventually exhaust itself and the only way for us to endure will be to emigrate to another solar system."

The more we know about the worlds far from our own home, the better we can choose our destination when the time comes, he says.

If on that epic voyage to the stars humans encounter other intelligent life forms, they may be surprised to learn that those beings are already well acquainted with the Earth and its people—including an astronomer known as Valentin Boriakoff.

Boriakoff's photograph is one of 118 images encoded on a copper disk carried aboard the two Voyager spacecraft sent out 12 years ago to explore the outer planets. Now that Voyager 2 has completed its historic encounter with Neptune, both Voyagers are on their way out of the solar system and into the vast reaches of the universe.

The disks carried by the Voyager spacecraft are records of the sights and sounds of Earth, designed to introduce residents of distant star systems to the builders of the space probes. In addition to the photographs, there are recorded greetings in virtually every Earth language, natural sounds ranging from falling rain to whale songs, and a fairly extensive library of the world's music.

Boriakoff was a research scientist at Cornell University in the late 1970s when Cornell researchers Frank Drake and Carl Sagan came up with the idea for the disk. Because of Boriakoff's expertise in electronics, Drake asked him for advice on how to put photographs on a traditional record.

"They didn't want word of the idea getting out, so at first Drake didn't tell me why he needed the information," Boriakoff remembers. "After about a week, he told me what it was all about."

With the help and generous support of a firm known as Colorado Video, Boriakoff solved the problem of encoding visual images in the grooves of a record. (The secret was converting the normal wide-band TV image into a low-frequency signal.) He also helped gather a few of the photographs chosen for the high-tech photo album and supervised their recording.

"For two months, I lived in airports," he remembers.

The photo record conveys a wide spectrum of human anatomy, activity and diversity as well as a variety of the Earth's scenery. Also included in the photos and on an engraved "record jacket" are images that explain how to play the record, how to interpret its information and how to figure out where and when Voyager began its voyage.

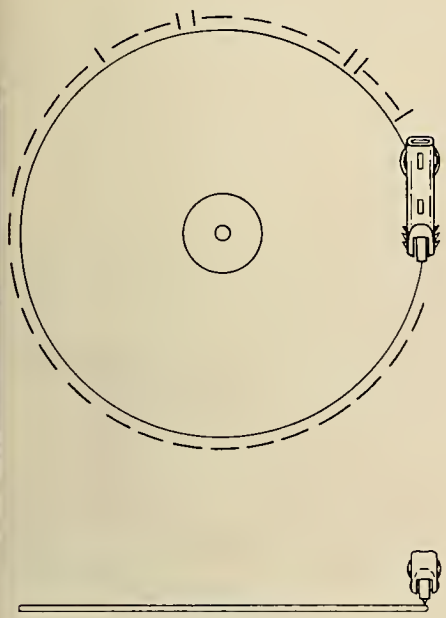
One of the first images seen is a solar spectrum—essentially the signature of our Sun—a photograph taken by Boriakoff to give viewers a way of pinpointing the Earth's home solar system.

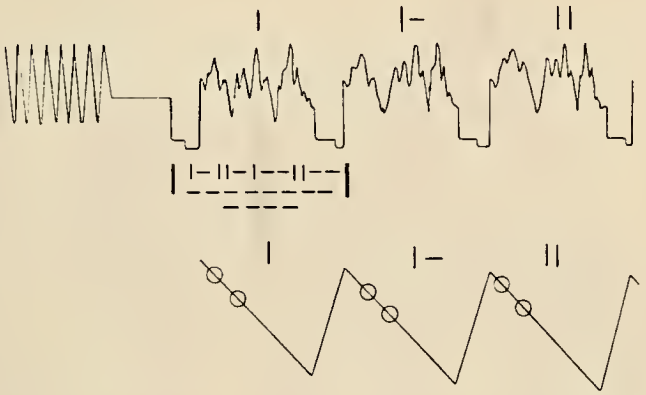
Boriakoff was also responsible for the one image of violence that appears on the record. "The creators of the disk did a good job presenting all the nice sides of humanity," Boriakoff says, "but war and killing animals and using the Earth's resources for our own survival were not represented at all. So I took the liberty of presenting this aspect of our civilization to Drake and Sagan, but they didn't like it. But, in the end, they did use one picture of Aborigines killing a deer to show both hunting and man's relationship to nature."

The photo of Boriakoff on the disk was designed to show beings from other worlds how humans eat and drink. In the center of the photo, Boriakoff is about to bite into a tuna fish sandwich while a woman to his right licks an ice cream cone and a man to his left drinks water from a carafe.

"I don't even like tuna fish," Boriakoff says, remembering the day the photo was taken. "Someone else had to take a bite out of the sandwich to show what a bite looks

A photograph of Valentin Boriakoff, associate professor of electrical engineering, is one of 118 images encoded on a copper disk carried aboard the two Voyager spacecraft.





The drawings that appear on the record jacket of the copper disk serve as an "instruction manual" for residents of distant star systems. The illustrations at left suggest that the disk should be played with a stylus (enclosed on board); above, the frequency graphs indicate that the disk's signals should be decoded and converted into visual images.

like, then I held the sandwich as if I were about to bite into the other end."

In all probability, he says, the Voyager spacecraft will travel for millions, perhaps billions, of years and never encounter another sentient being. Scientists have been monitoring electromagnetic energy arriving at Earth from distant stars and galaxies for many years, and have yet to detect telltale signs of other civilizations, he says. In fact, it may be a characteristically human foible to expect that because intelligent life has arisen on Earth, it must have gotten started on other planets, he adds.

"Evolution happens only by necessity," he notes. "We got intelligence because that was the only way to survive. If having fins would have saved our ancestors, maybe that's what we would have, and not intelligence."

While Boriakoff has a healthy skepticism about the chances for finding life elsewhere in the universe, he has not, as some scientists have, completely ruled out the possibility.

"There are people who say, 'we don't see anybody, so maybe we are the only ones,' " he notes. "But that brings us back to the Middle Ages and the idea that we are the center of the universe."

Boriakoff's interest in the universe is not in alien life forms, but in a bizarre class of objects known as pulsars. First discovered in the late 1960s, pulsars are believed to be the remnants of stars that have exploded and then collapsed into extremely dense bodies known as neutron stars. Spinning at fantastic rates, these stars emit brief, highly regular pulses of light, X-rays, gamma rays or radio waves.

First as a graduate student in his native Argentina and later as a researcher at Cornell, Boriakoff performed ground-breaking observations on many of the more than 400 pulsars discovered to date.

Working at the mammoth Arecibo Radio Observatory in Puerto Rico, he became the second researcher in the world to find an unusual class of pulsars that spin as fast as twice every millisecond. The pulsing of these so-called millisecond pulsars has since turned out to be the most regular phenomenon known in the universe. In fact, Boriakoff, along with other researchers, has proposed that they replace atomic clocks as the universal time standard, a suggestion taken seriously by at least one international time-keeping agency.

In current research, Boriakoff is planning to search for pulsars in globular star clusters (dense patches of stars) and to use gamma ray emissions to find new pulsars. Earlier, a European space observatory detected a strong source of gamma rays in the vicinity of an object Boriakoff discovered, known as the six-millisecond pulsar.

That pulsar seems to be orbiting another star. Its enormous energy (a magnetic field a trillion times greater than the Earth's) may be stripping away the other star's outer layers—a phenomenon most likely responsible for the gamma ray emissions. He believes other pulsars may be found by looking at other gamma ray sources.

In addition to studying pulsars, Boriakoff, working at Arecibo, has helped produce a radar map of Venus, and, more recently, has studied the evaporation of water from Halley's Comet.

The latter project was conducted in Argentina and funded jointly by the National Science Foundation and the equivalent agency in Argentina. Boriakoff says he recently visited the Argentine Radio Astronomy Institute, where he began his career in radio astronomy in 1963, to begin talks aimed at launching joint research projects with the Institute and encouraging scientists there to turn their attention to pulsars.

There are few radio observatories in the Southern Hemisphere. As a result, this section of the sky, from which scientists can get their best view of the center of our own galaxy, has been little studied. "There are unexplored treasures there," he says.

As he gazes toward the sky on clear nights or pores over data from Arecibo, does Boriakoff ever think about that copper disk carrying his image toward some distant star? Does he wonder about the chances of that simple photograph living on long after the Earth and all its people are gone?

"Actually," he says, "I feel my immortality more in my children, than in a picture forever floating out there. After all, who will ever see that?"

—Michael Dorsey

A WORLD OUT OF BALANCE

BY AMY ZUCKERMAN

Americans want the benefits of technology without paying the price. It's time we decided how safe is safe enough, say scientists and engineers.

In his 1970 book *Future Shock*, Alvin Toffler wrote of a world in which society is driven by technology. Nearly 20 years later many experts in risk analysis and risk management believe that we are now living in the world that Toffler described.

"There's one huge flywheel of technology turning faster and faster," says Richard L.P. Custer, associate director of WPI's Center for Firesafety Studies. "It's getting harder to turn it down or change it."

Floyd R. Tuler, associate professor of mechanical engineering, feels society is losing out by allowing technology to dictate societal decisions. Technology should be neutral, Tuler says, "but we don't treat it that way."

Tuler, Custer and other WPI researchers and alumni say that society's expectations and desires are "out of whack," that we have come to depend on technology to provide a comfortable standard of living, yet we give little thought to the health, safety and environmental consequences that inevitably accompany technology.

The message these experts have for society is simple: "You can't have it all." You can't have automobiles without air pollution. You can't use toxic materials in the manufacturing process and not produce hazardous by-products. You can't generate electricity with nuclear power plants and not build repositories for radioactive waste. You can't operate complex machines and not accept the risk of accidents.

There is a price to pay for our advanced industrial society and our modern lifestyle, they say. That price includes the cost of correcting and cleaning up after technological mistakes, and the price of giving up conveniences—like aerosol propellants—when they pose unacceptable risks.

There was a time, not long ago, when answering questions about risk was a much simpler task, Tuler and Custer note. Engineers and scientists whose job it was to assess and manage risk spent most of their time maintaining and updating existing fire, building and safety codes.

Highly publicized disasters like the Challenger explosion have eroded public confidence in technology.

The public was in the midst of a love affair with technology then, demanding newer and greater feats of technological wizardry with little concern for, or understanding of, the side effects.

Then television news began bringing frightening pictures of disasters, in living color, into our living rooms. One by one, the images marched across our screens—Love Canal, massive oil spills in Santa Barbara and Alaska, Three Mile Island, the collapse of the L'Ambiance Plaza in Bridgeport, Conn., Chernobyl and the Challenger explosion.

These failures, disasters and miscalculations of risk, along with more personal encounters with faulty and dangerous products, eroded public confidence and many people found themselves growing less enchanted with technology. Public awareness of the risks of modern technology spawned vast amounts of new regulations and laws and helped create our increasingly litigious society, a society in which juries are inclined to award large settlements to individuals no matter who is at fault.

Tuler, Custer and others involved in this field say they feel trapped by these trends. They say they find it difficult to meet the demands and expectations of a society that wants its technology risk-free.

Society simply doesn't understand risk analyses, argues John A. Mayer Jr., director of WPI's Nuclear Engineering Program. He says, for example, that people will accept the risk of dying in a traffic accident because, while accidents kill tens of thousands of people each year, the toll from any one accident is small. But many people no longer accept the risks inherent in operating nuclear power plants because, while the real human toll from nuclear power each year is very small, there is a perceived risk of large-scale catastrophes.

One answer to the growing rift between public expectations for technology and concerns about technological risk is education, note all of the experts interviewed for this story. They say society—the public, government and industry—must make up its mind what amount of risk is acceptable. And engineers and scientists have a responsibility to help them do that—to educate the public about the realities of risk and technology.

Francis Noonan, associate professor of management, argues that most of the developments in risk management have come from the discipline's two main divisions: corporate risk management, which includes the field of insurance, and societal risk management, the more academic side. He says engineers are not well represented in either division, and consequently much of what is disseminated to the public tends to be biased against technology. Noonan calls for engineers to take charge of this newly developing field, to move in and make their attitudes clear.

A better educated public can play a bigger role in making decisions about technology and will be better prepared to accept the outcomes of those decisions, notes Mayer, who as the chairman of the Massachusetts Low-Level Radioactive Waste Management Board, has recommended giving communities a role in operating waste facilities, whether they involve hazardous or solid wastes.

"What do we do about our high volumes of solid waste? Of hazardous wastes? Of

Forensic engineer Ray Hagglund (right) says Americans sue all too easily when technology fails.

Our values often keep us from seeing technology realistically, notes Jim O'Shaughnessy (below).

Unrealistic expectations about technology are stifling progress, says Floyd Tuler (right).

PHOTOS BY PATRICK O'CONNOR

solvents?" Mayer asks. "We have to find sites for these wastes or our industrial society will come to a screeching halt. We can't go back to a rural society. We need the support of technology. When people talk about risk, they should know that the biggest risk is doing nothing."

What follows is a look at the role four WPI faculty experts in risk assessment and risk management are playing in fields where engineering meets the real world.

Floyd Tuler: Improving the Odds

Whether he's studying trucks that carry compressed gas on Massachusetts highways or analyzing the development of safe evacuation plans for offshore oil rigs, Tuler's interest is in minimizing risk. To do that, the associate professor of mechanical engineering has to keep in mind what level of risk is acceptable in the eyes of the public.

"Engineers can do all the technical analyses they want," he says, "but they must understand what society wants and then make the public understand the risks involved."

In his consulting work, Tuler has seen cases where technological advances have improved risk assessment and made it possible to implement better safety features. One example is a study he completed for FIBA, a Westboro, Mass., company that builds and inspects trucks that carry compressed gas.

FIBA asked Tuler to study how cracks develop in the cylinders that contain the compressed gas. Under the company's existing maintenance schedule, trucks were allowed to go five years between inspections. FIBA wanted to know the likelihood that flaws that developed between inspections could result in catastrophic failures.

Tuler conducted a fatigue life and fracture analysis of the cylinders using a relatively new inspection technique known as acoustic emission. The technique, which is more precise and less expensive than older techniques, uses sound waves to probe the structure of the metal tubes and determines where cracks are beginning to form. Once a flaw is located, Tuler says the next question is whether "it's big enough to worry about. How big is bad enough to make the tube burst before the next inspection?"

"Society has to decide what's acceptable, and that's the part that's controversial. Some say no risk is acceptable."

With the new technique, Tuler demonstrated that the existing schedule is conservative and safe.

The nature of risk is a relative one, Tuler says. He notes that as a society we accept the risks associated with inherently dangerous technology because it helps maintain our standard of living. As examples, he cites the dangers of living and working on offshore oil drilling platforms, and the risks these platforms pose to the environment.

As part of a study of how the United States, the United Kingdom and Norway compare in the management of offshore oil rig safety, Tuler looked at how the location of sleeping quarters on the rigs affects safe evacuation times. Tuler made suggestions that may improve the odds that workers will escape from a burning or sinking platform safely, but he notes that these changes can't guarantee that an accident won't occur or that lives won't be lost.

"Society has to decide what's acceptable, and that's the part that's controversial," he explains. "Some say no risk is acceptable."

This "no-risk" attitude has had a major impact on court cases involving technology. "Liability is ruling the day," Tuler says. "There are many examples of companies that have decided not to pursue ideas because of the threat of liability. Maybe lawyers aren't exactly directing technological growth, but they're certainly affecting it."

Tuler said he has had firsthand experience with the type of court case that makes companies nervous. One suit was brought by the family of a two-year-old child who lost an eye when an aerosol can fell or was knocked onto a hot stove and exploded. The case was settled out of court for more than half a million dollars.

Tuler, who served as an expert consultant on the case, said the injury was clearly the result of human negligence, and not any fault of the technology. Under those conditions, he says, "the can should have exploded."

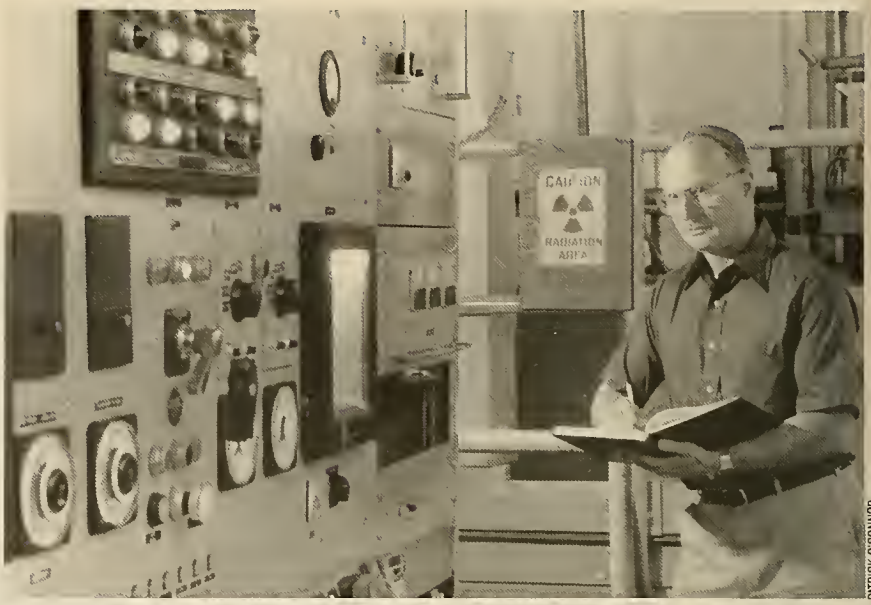
Still, as a result of this incident, and others like it, the public has been forcing industry to look for alternates to aerosol cans for products used in the kitchen, a development Tuler says he isn't convinced is realistic or necessary.

Raymond R. Hagglund: Taking the Stand

A forensic engineer, Hagglund spends a great deal of his time serving as an expert witness in product liability cases, a pursuit that gives him a firsthand look at how supply and demand affect technology—sometimes for the worst—and the impact litigation can have on the pace of technological change.

A few years ago, the professor of mechanical engineering was a consultant for a company that manufactures propane gas valves. After studying one of the company's new valves, Hagglund concluded that there was a high risk the valve would fail while in use. But the manufacturer ignored his recommendations and pushed the product onto the market. Six years later, while investigating a gas explosion in a house, Hagglund discovered that his

WELCOME TO RISK 101



PATRICK O'CONNOR

Future engineers and scientists must learn to work in a risk-conscious world, notes John Mayer. It's a process that should begin as early as elementary school.

Despite the WPI Plan's emphasis on educating socially conscious engineers, scientists and managers, there are those on the college's faculty who fear that students are not being adequately trained to live and work in a world where risk analysis and risk management are playing increasingly important roles and where decisions about technology are increasingly colored by social values and public concern.

Francis Noonan, associate professor of management, has been trying to convince the National Science Foundation that there is a need for a risk management curriculum for engineering colleges. He would like engineers and scientists to take a course that covers "modeling uncertainty," or the ability to analyze the state of any system or process "when it's permeated with uncertainty."

Noonan also feels that engineers must better understand societal values in order to communicate information on risk to the public.

Besides covering these topics, Noonan says the curriculum should include units on the formal processes of risk analysis and management; the engineering economy, or how to make business decisions in today's risk-conscious environment; and decision analysis, which focuses on modeling uncertainty and dealing with complex value systems.

Students should begin learning to understand and coexist with technology in the elementary grades, says John Mayer, director of WPI's Nuclear Engineering Program. "They don't have to be designers," he says, "but they have to understand something about the role of technology—its promises, as well as its difficulties. They must understand that technology is neutral. It's how you manage technology that matters."

According to Mayer, people accept technology when they understand what it can and cannot do. He lauds the WPI Plan for requiring college students to "examine the interface between technology and society, with the major charge of the Plan being the education of technologists who understand their obligation to society."

Others, like James O'Shaughnessy, head of the Civil Engineering Department, say technological changes will eventually have a major impact on the education of engineers and scientists. "The new emphasis on eliminating hazardous materials from products in design and manufacturing, for example, will change the way we teach engineering."

predictions had come true—the company's valve was the apparent cause of the explosion.

At the time, two million of the valves were on the market. The company ordered a recall, but thousands remained at large. Those that were returned had to be rebuilt. "At $40 a valve, you're talking $80 million and a potential loss of life, and all because one man was moving up in business too fast," Hagglund says.

While technology was the culprit in that instance, Hagglund faults lawyers for encouraging the public to believe that "whenever there's an accident, someone should pay."

He recalls the case of a New Hampshire man whose gas was disconnected for nonpayment. He brought home a propane heater, hooked it up to the gas line and then sued the gas company and the Japanese firm that manufactured the gas line valve when the heater exploded. Hagglund says the man claimed the two companies were negligent for not putting up a sign explaining what could or could not be hooked up to the line.

"The case went to trial and there was a settlement," he says. "There's always money in a suit and always money in a settlement."

Acting as witness in case after case, Hagglund has found public attitudes about technology and risk increasingly annoying. He says people should understand that there are problems and accidents no one can prevent.

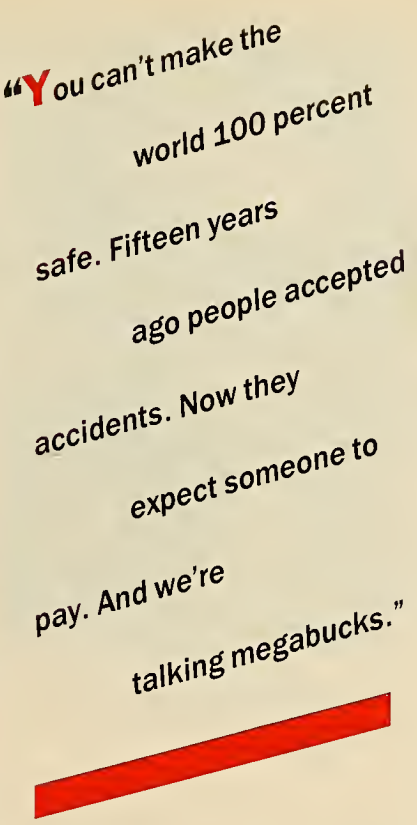
"Look at auto accidents," says the forensic engineer. "We're always going to have them. Still, whenever there's an accident, someone sues.

"You can't make the world 100 percent safe," he insists. "Fifteen years ago, people accepted accidents. Now they expect someone to pay. And we're dealing with megabucks."

Although Hagglund has seen industry make "giant steps" in its commitment to product safety during the last decade or so, he says there are some products that cannot be made completely safe. A power saw, he notes, is inherently dangerous if misused.

"People just aren't careful. I had a case where a doctor cut off his fingers using a table saw. Sometimes people just have to act responsibly."

If he would change anything, Hagglund says he would train juries to be more knowledgeable about the law and about technology, "and to be better able to balance emotion with fact. That comes with experience."



Richard Custer: Dousing the Flames

Custer says he has seen many examples of new technology—particularly technology that enables scientists to measure things more precisely (for example, laboratory techniques that enable scientists to measure pollutants at minute levels)—creating new demands for safety. This has been especially true in the field of firesafety, he says.

Fifteen years ago, says the associate director of WPI's Center for Firesafety Studies, engineers approached firesafety risks "by looking at the codes, which were some standards of practice developed by a consensus of engineers and other professionals. We designed buildings by a set of rules determined this way. But these codes were based on very little actual calculation of fire-related hazards. It was not possible to predict how serious a risk a building posed before that building was designed."

Back then, Custer says, firesafety engineers ignited a lot of materials and watched how they burned. But these techniques didn't always take into consideration such important variables as the size and shape of a room or how materials actually behave in certain environments. "There was no way to tell how serious a fire in those materials might become in a particular room," Custer says.

For example, Custer notes that flames won't spread easily on some materials if they're placed flat on a ceiling. But those same materials will "burn like hell if placed in another configuration.

"Today we can take information on materials and how they burn and incorporate them into computer models that give us a much better understanding of risk," Custer says. Armed with better analytical techniques, fire protection engineers can tell architects and designers how to create structures that will contain fires. "This is the sort of work that civil and mechanical engineers have traditionally done. But not until recently has it been done in the field of firesafety."

But better information and new technology can create their own problems, Custer says. For example, along with more accurate techniques for measuring risk comes increased public expectation for safety. And as public expectations grow, there will be more lawsuits.

"There's the assumption that we should have known how to prevent a problem," notes Custer. "The leading edge or cutting edge of technology is creeping into what were formerly fire codes based on consensus. Once new technologies and new standards of measurement end up in the codes, people will use them in court."

James O'Shaughnessy: Balancing Values

In his work as an environmental engineer, O'Shaughnessy faces value questions every day. In particular, he finds it frustrating to try to "get people to accept a structured or engineered solution. It just doesn't happen. People have different values."

As an example, the civil engineering department head points to the confusion over clean water standards. As the standards for waste water have become more stringent in recent years, they have sometimes surpassed standards for drinking water. There have been proposed regulations, for example for copper, that may prohibit drinking water from legally being discharged into rivers or lakes. O'Shaughnessy says this is one problem that researchers have yet to resolve.

Society has to set priorities and make decisions about risk, O'Shaughnessy says. "Products that create toxins give us an easier lifestyle," he says. "We don't have to return the milk bottle to the store and that gives us more time for other things. That's a value issue because there's a tradeoff involved. That's what risk assessment is all about. Unfortunately, values depend on you and your own lifestyle."

O'Shaughnessy says a new hazardous waste law in Massachusetts is a good example of how society can sometimes decide to accept more stringent regulations. Under the law, a compromise hammered out between environmental groups and industry, Massachusetts industries have agreed to cut their current use of hazardous materials in half by 1997, a step that will require many industries to change the way they manufacture products.

Sometimes decisions that reduce societal risk can actually make life easier for individuals and corporations. For many years, environmental regulations have focused on how to dispose safely of the waste produced by industry. In recent years, the U.S. Environmental Protection Agency and many state agencies have begun to focus on source reduction, or how to avoid producing the waste in the first place.

O'Shaughnessy has worked with the Massachusetts Department of Environmental Management on pilot source reduction programs in various parts of the state. He says industries that have worked to reduce their waste, including a number of metal plating businesses in southeastern Massachusetts, have found that the effort often makes their manufacturing operations more efficient and cost effective.

Like water pollution, problems of airborne hazards are a major environmental issue. But while air pollution experts continue to study discharges from smokestacks and cars, O'Shaughnessy says indoor air quality, especially problems caused by the discharge of hazardous chemicals from building materials and furniture, "is just coming into focus," as are the health threats posed

ENGINEERING MEETS THE REAL WORLD

Even "fireproof" buildings can burn, notes Ralph Sellars. He says people are not as familiar as they should be with the routine hazards around them.

Kenneth Gminski says the growth of high technology has magnified the risks faced by many businesses, which can now suffer huge losses from a simple room fire.

Practicing risk assessment and risk management are no less complicated undertakings in the field than they are in the laboratory, the classroom or the courtroom.

Kenneth A. Gminski '68 spends his days visiting companies and assessing their fire risks. Gminski is a loss prevention consultant for Factory Mutual Engineering Association, an industrial property insurance and loss control organization in Norwood, Mass. In the 18 years since he joined Factory Mutual, Gminski says "the business has changed tremendously."

"The basics are there, but the technology has changed and we've had to grow along with it." Gminski visits many computer firms that have millions of dollars worth of equipment in a single room. That translates to "bigger and bigger risk," he says.

While the magnitude of the risks that companies face has increased "immensely" in recent decades, Ralph E. Sellars Jr. '58 says not much has changed in the field of fundamental fire protection during the same period of time. Sellars, manager of loss analysis for Factory Mutual Research, says what has changed are people, "the new generation, who are less knowledgeable than the generation they have replaced.

"People aren't as cognizant of ordinary, routine hazards that exist around them," Sellars says. "People perish in buildings year after year because of combustibles used in construction and furnishings. The owners of these buildings have been led to believe that because you build a fireproof building, it will be safe." Concrete may not burn, Sellars says, but furnishings certainly will, "far more readily than people realize."

Managers who want to pay attention to firesafety can get caught between short-term and long-term costs, a situation Sellars feels would be remedied with more education or publicity on fire and on safety fundamentals. "WPI is one of the few schools in the country that offers a master's degree in fire education," he notes.

Gerald J. Parker '66 is caught in a real environmental Catch-22. Trained as a chemical engineer and an avowed environmentalist, Parker is currently chief of the Environmental Compliance Branch of the Office of Civilian Radioactive Waste Management of the federal Department of Energy.

Parker is often caught up in a particularly emotional version of what many in the risk management field call the "NIMBY" (not in my backyard) syndrome. He's even been hung in effigy. It's Parker's mission to locate an underground site for a nuclear waste repository. With about 140 nuclear reactors in the United States and space in temporary waste storage pools running out fast, Parker and his agency are hustling to find a solution to the storage problem.

"But no one wants to face up to the storage issue," Parker says. "There are solutions, but a potential site in Nevada is in question and no one else wants it. This is the perfect example of no one wanting to accept any risk. Somewhere, someplace, someone has to take a risk. It makes sense to go underground technologically, but politicians keep overriding (this solution)."

Having dealt with this issue for a number of years, Parker has a word of warning for all WPI students heading out into the field. "It's gotten so that politics and society's attitudes are as important as engineering."

---

by radioactive radon gas trapped in buildings (see story, page 11).

Despite recent strides, O'Shaughnessy sees the problems of hazardous waste dominating environmental engineering for the next 25 years, "unless we change our whole lifestyle." It's that lifestyle, envied the world over, that may pose an important new problem as we head into an era when environmental issues become increasingly global.

"Developing countries that don't even have what we consider basic necessities—countries faced with starvation or a lack of decent water supplies, are willing to accept more pollution to gain a better standard of living," he says. "These countries are not likely to develop tough standards for hazardous materials. That's why we have people dying in Africa from exposure to pesticides, for example. What would happen if these countries developed the same standard of living as the developed countries with the attendant energy requirements and toxic waste production?"

The conflicting interests of developed nations, which want to reduce pollution and curtail development, and those of developing nations, which want to grow at any cost, may be one of the most significant issues in environmental engineering in the years ahead, he says.

Zuckerman is a writer for Worcester Magazine. *She last wrote about the college's calculus curriculum for the* WPI Journal.

Confronting a Clear and Present Danger

By H. Davis Bushnell

A major announcement a year ago by the U.S. Environmental Protection Agency concerning the hazards of radon gas was dispiriting to homeowners, but heartening to fledgling business owner Richard F. Abrams '70.

As have an increasing number of entrepreneurs, Abrams has tied his firm, founded in 1987, to a major environmental issue. When the EPA reported that high levels of radon in houses are causing an estimated 20,000 lung-cancer deaths annually, Abrams was in the process of securing additional financing to produce a radon-reduction system.

"The timing of the EPA announcement was perfect," says the 40-year-old chief executive of RAd Systems, Inc., in Westborough, Mass. "The business that we're in—reducing and controlling radon gas levels—exploded."

Radon is a radioactive gas produced when uranium in the soil and in building materials decays. It is also produced by rocks containing granite, shale, phosphate and pitchblende.

Like the oil furnaces it resembles, the RAdsorb-222, RAd Systems' product, is designed to be placed in the basement where radon generally enters a house. It is the only device of its kind currently on the market, Abrams claims, adding that he has obtained a United States patent for it and has applied for international patents. The system is installed by contractors for between $2,500 and $3,000 and is generally used when a mitigation technique known as the subslab ventilation method won't do the job.

High radon levels, which the EPA links to lung-cancer deaths, are a problem for many homeowners. A new company founded by Richard Abrams '70 offers a high-tech solution.

The subslab method, which extracts radon gas from beneath a house, is currently the most common one used, says Jed Harrison, branch chief for mitigation and prevention of the EPA's radon division. The EPA estimates that 10 percent of all U.S. houses, or about eight million, could have radon levels of 4 picocuries or higher for each liter of air. (A curie is a measure of radiation; pico denotes one-trillionth.)

Systems that reduce radon at the source and control the problem have the greatest potential to lower the risk to homeowners, Harrison says. While the EPA does not "have a formal product-approval program," he says the RAdsorb-222 has been loaned to the EPA and is being tested in Tennessee.

Abrams, meantime, is accelerating research so that he can, within a year or so, introduce a second product that will be price-competitive with the subslab method. Despite the pricing challenge, his system does the job and he has the results to prove it, Abrams insists. "When our machine was installed for the EPA's Nashville project," he notes, "it reduced the radon level in a house from 11 picocuries to 0.9 picocuries within an hour and a half."

The RAdsorb-222 contains two beds of activated charcoal. Room air is drawn through the first bed, which adsorbs the radon gas. As the first bed approaches its saturation level, the air flow switches over to the second bed. In the meantime, outdoor air is passed over the first bed in a direction opposite to that of the indoor air. The outdoor air removes the radon from the charcoal and carries it outside the home.

Continual cycling between the beds prevents radioactive material from building up on the charcoal, Abrams says. Using outdoor air to flush the beds minimizes heat loss and also avoids the depressurization that can be caused by devices that simply vent basement air to the outdoors. Abrams notes that the activated charcoal in the beds also removes many other air pollutants, a claim that can be made about no other radon removal device.

Twenty-five units are now installed in houses in the Northeast. Abrams forecasts sales of between $500,000 and $750,000 for 1989, compared to zero for 1988. If 45 to 50 units can be sold each month, "positive cash flow should be achieved in 1990," he says.

He first realized that a radon reduction system had possibilities when he worked for Koch Process Systems, Inc., in Westborough, Mass. "I dealt with removing radioactive gases from nuclear power-plant effluents," recalls Abrams, who majored in chemical engineering at WPI. "Radon is in the same family of gases, and I had read up on the radon issue, which first emerged outside Philadelphia in 1984."

After developing an idea on his own for a carbon-bed system that would trap and then purge radon, he left Koch in January 1987 and worked further on the project in his Westborough, Mass., home. He produced a one-quarter scale model and took it to the University of Pittsburgh for testing. The tests were successful and, in September 1987, he raised $125,000 to refine the system.

"I expect these devices to be stepping stones to a range of equipment aimed at solving a variety of indoor air problems."

A full-size prototype—"ugly but functional"—was built in the spring of 1988 and installed in a Merrimack, N.H., house that had high levels of radon. Within three hours, the radon level had been reduced from 14 picocuries to 1 picocurie (the EPA recommends that home owners take remedial action when levels rise above 4 picocuries). "So the system worked and it worked predictably, one of the major goals."

A second round of financing, totaling $590,000, was secured from corporations and individuals in the fall of 1988. Abrams then retained a Boston marketing consultant who devised a plan to line up mitigation contractors to sell the devices to homeowners.

The first contract manufacturer proved unsatisfactory, so another one had to be found, which resulted in a delay in the first shipments of units. The delay, plus the financial transfusions, made Abrams realize that he was no different from any other entrepreneur.

"When people told me two years ago that such an undertaking would take more time and money than I could envision, I didn't believe them," he says. "But I do now. We're doing well in sales, the market potential still looks great, but I'm sure that another financing round won't be far off."

Currently, Abrams is preparing to market a new device that will remove radon from water. The EPA considers radon in household water supplies to be a major health hazard, causing between 100 and 1,800 excess cancer deaths in the U.S. each year, Abrams notes. Next year, he says, the agency will establish a maximum permissible level for radon in drinking water that will likely be exceeded by about 90 percent of well water in New England.

Radon can dissolve in groundwater as it passes through soil or porous rock (water in reservoirs is generally exposed to air long enough for most of the radon to dissipate). It poses little or no threat if ingested, but when the water is exposed to air, the gas can become airborne and increase one's risk of lung cancer. The largest releases occur when the water is both exposed to air and heated, so showers, dishwashers and washing machines are important sources.

It has been estimated that water containing 1,000 picocuries of radon (not an uncommon amount for groundwater) will cause an extra 3 to 13 lung cancer deaths per 10,000 individuals. Groundwater radon levels in the Northeast can run as high as 1 million picocuries.

Like the RAdSorb-222, the unit Abrams has developed to remove radon from water employs a regenerating charcoal adsorber. The radon is trapped on the charcoal and periodically purged and vented outdoors. The compact, patented unit requires little floor space and operates automatically.

"I expect these devices to be stepping stones to a range of equipment aimed at solving a variety of indoor air problems," Abrams says. "It's becoming clear that indoor air is dirtier than outdoor air and this may well prove to be a large growth area for us."

Abrams sees many untapped markets for his products, including government and school buildings. "And Europe, especially the Scandinavian countries, has the same radon problem as the United States," he notes. To reach those markets effectively, RAd Systems would have to be acquired by a large company, which is a distinct possibility within five years, he adds.

"That's really my goal," he notes. "Being acquired would enable me to do other things I have in mind."

Bushnell is editor of Business Digest *in Worcester.*

Underground aquifers provide half our nation's drinking water. What happens when toxic wastes foul these crystalline reserves? One city found out the hard way.

BY LISA HOOKER

Danger Below

The "No Trespassing" signs don't deter butterflies flitting across the meadow at the North End of Hamilton, Ohio. They swoop among the masses of purple thistle, oblivious to the wells silently pumping water from the ground 24 hours a day, seven days a week.

A barbed-wire fence separates the wildflowers from the neighborhood; a breeze ruffles the tall grass and carries the sound of a bat thunking against a softball. The six ballfields just east of the meadow shimmer in the afternoon sun. On one diamond, a handful of men and women play a lazy game, more interested in tanning than in winning.

North of the ballfields and the meadow, the Ford Hydraulic Canal meanders west, heading for the Great Miami River. The factories that support Hamilton follow the canal west: a sheet-metal plant, a machinery company, a paper factory. South of them all stretch streets of working-class homes, small businesses, taverns, and—less than a mile from the meadow—downtown.

Beneath the meadow, the homes, and the factories lies the Great Miami Aquifer, a two-mile-wide, 80-mile-long water basin that roughly follows the Great Miami River. The aquifer, one of the Midwest's most productive, supplies one-third of the groundwater used in Ohio. It rises to within 20 feet of the ground.

On this summer afternoon, light glints off 133 aluminum squares nestled among the meadow's tall grasses. The metal caps cover wells, a cobweb of connected pipes leading from the surface down to the aquifer. From the bleachers of the softball field, the well caps are as impossible to see as the water coursing through the aquifer below.

The meadow has a mailbox and an address: 500 Seventh Street. Home of Chem-Dyne Trust, a company with one product: clean water. It will take at least a decade and more than $20 million before the business can be pronounced a success.

CINCINNATI INQUIRER

Chem-Dyne Corp. began as a small business in 1974. But its name soon came to represent one of the largest hazardous waste sites in Ohio. In its six years of operation, Chem-Dyne accepted wastes from nearly 300 companies. Most of the waste never left Hamilton, a city of more than 66,000 residents.

When cleanup of Chem-Dyne's industrial park finally began in May 1983, contractors found 8,600 drums, 30 storage tanks, and two open-top tanks sprawled across the 10-acre property. All were full of hazardous liquids and sludges, and most were leaking. They contained more than 300,000 gallons of toxic waste: pesticides and rat poisons, waste oils, plastics and resins, acids, arsenic and cyanide sludges. The chemicals involved sound like a witch's version of alphabet soup: DDT, PCBs, TCE, PBBs, TRIS. There were huge vats, where chemicals had been mixed in the hope of producing a new product—antifreeze, perhaps, or low-grade fuel oil.

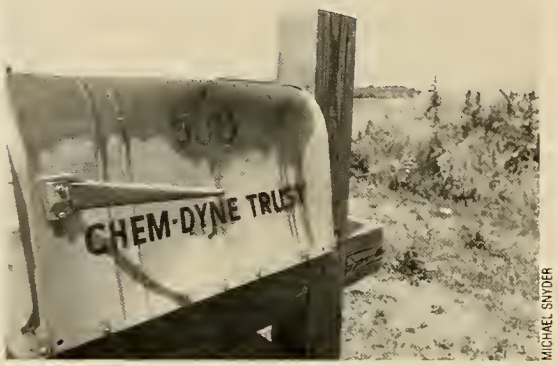
But the sight that made officials blanch was the row after row of empty gravel pits, into which chemicals—millions of gallons of them—had been dumped when Chem-Dyne received more waste than it could store.

In December 1980 Congress enacted the

Comprehensive Environmental Response, Compensation, and Liability Act. Most people know the act as Superfund. The U.S. Environmental Agency (EPA) decided to use Chem-Dyne to test Superfund in court. Chem-Dyne emerged as the leading Superfund case in the country, the first test of the government's power against industry's will. The case also marked the first time anyone argued that a company ought to pay for more than just cleanup—that there should be "natural resource damages" as well.

For nearly a decade, two men waged a war over Chem-Dyne: Hal Shepherd, Hamilton's assistant city manager; and William Kovacs, co-founder, spokesman, vice president, and in the end, sole owner of Chem-Dyne. Shepherd won; Kovacs finally lost the company to a state receivership appointed to sell off Chem-Dyne's assets and clean up the mess.

After oozing millions of gallons of hazardous chemicals into the ground, the 8,632 drums and tanks at Chem-Dyne (far right) have now been carted away. A meadow has taken their place. But restoring the poisoned water beneath the site will take 10 years and $20 million.



MICHAEL SNYDER

But the receivership didn't solve the problem: There weren't enough assets to complete the job. And when the city tried to go after Kovacs and his company, he declared bankruptcy. Shepherd fought him all the way to the U.S. Supreme Court, but the bankruptcy held. In the end, Kovacs walked away untouched. Although state and local officials say Kovacs was responsible for one of the worst hazardous waste dumps in Ohio's history, he violated no criminal laws. In 1974, there were none.

Because Kovacs could not be held responsible for Chem-Dyne's cleanup, the EPA used Superfund to go after the companies that had created the waste in the first place, the companies destined to become Chem-Dyne Trust.

When John Boland first visited Hamilton in 1984, the meadow didn't exist. The environmental economist instead found himself in a 10-acre dead zone less than a mile from town. He came to tell the city what it had lost, in land that it probably would never sell, in water it couldn't use, in an image perhaps forever damaged.

Back in Baltimore, at Johns Hopkins University, Boland was a scientist. In Hamilton, he was one of the expert witnesses called in to settle a battle between the city and a now-abandoned business.

"The city had a glimmering of what was going on for years," Boland says. "But no one had any idea of the extent of the damage."

Shepherd thinks back on eight years of phone calls at 3 a.m., pickets in front of his office, and threats made on his life. He recalls how, while fires blazed at Chem-Dyne, he had to beg a judge for a search warrant because Chem-Dyne officials wouldn't tell him what chemicals were on fire. He riffles through letter after letter to state officials, requesting assistance. He sighs.

"My feeling is that Kovacs should be hanging at the end of a rope."

Groundwater provides more than half the drinking water consumed by Americans today. It is generally pure, requiring little or no treatment before use. Unless, of course, the water has been contaminated.

Kovacs and three partners opened Chem-Dyne Corp. on a four-acre lot in 1974. They were attracted to Hamilton's pro-business climate and cheap land. Chem-Dyne billed itself as a "hazardous material recycling facility," and for the first two years, tanker trucks and semis loaded with 55-gallon drums drove in and out of town unnoticed. Nobody paid much attention when the company began encroaching on the abandoned lots next door, stacking drums four and five high like a fence around the property. The lot grew quickly from four acres to 10.

Two years after Chem-Dyne opened, the fish in the Great Miami River began to die. That year—1976—one fish kill beginning at the mouth of the Ford Canal stretched almost 37 miles, all the way to the Ohio River. More than one million fish died.

The fires started about the same time as the fish kills. Firefighters repeatedly raced to North End to spray cold water on 300-gallon tanks that shimmered with heat, one chemical reaction away from exploding.

"At first, nobody thought much about it," recalls Ron Holt, who used to work at a nearby graveyard. "I used to play baseball right across the street. We even had a hole cut in the fence for flyballs. Sure, it didn't smell great—but it just smelled like a factory.

"You just don't think something like that could be there," he adds. "You know, though, the fire chief said his hoses actually started to rot sitting on the ground."

Once the fires started, the legal battles flared up as well. Hamilton sued Chem-Dyne for having violated local ordinances. Chem-Dyne sued Hamilton for harassment. The state of Ohio sued Chem-Dyne for the fish kills. The lawsuits kept Shepherd and Kovacs in courtrooms for most of the '70s. The city and state later joined forces, and eventually Chem-Dyne agreed to drop its lawsuit, remove the barrels of waste chemicals, and pay $75,000 in fines. But until the federal government stepped into the fray in 1980, the company continued to operate.

When Chem-Dyne had opened for business in 1974, there was no national policy on groundwater to guide states struggling to control pollution. Fifteen years later, there still isn't one. Two federal agencies and one department share responsibility for groundwater at the national level: the EPA, the U.S. Geological Survey, and the Department of Agriculture.

Three federal laws are expected to address the complex issues of groundwater testing, protection, regulation, and cleanup. One law is the Safe Drinking Water Act, which requires the EPA to formulate maximum contaminant levels, or standards for allowable levels of contaminants in water. Congress asked the EPA to have 83 standards ready by this past June, but so far only 30 exist. Another law is the Clean Water Act, which the EPA can use to help—or force—a state to protect its water supplies by providing or withholding federal funds. This act has been used primarily to clean up surface water.

A third law is the Resource Conservation and Recovery Act, which requires compa-

Lisa Hooker is a Baltimore-based science writer with a special interest in environmental issues.

nies to keep track of the hazardous waste they produce and to dispose of it properly. Known as the "cradle-to-grave" law, the act holds companies responsible for their waste even after they turn it over to someone else. It also regulates municipal solid waste disposal and underground tanks.

That law didn't exist in 1974. Neither did Superfund. Together, they give the federal government authority to clean up hazardous waste sites that states cannot or will not address. All the federal laws, however, stress the need for state action, state laws, and state funding if groundwater is to be protected. In the end, each state is responsible for itself.

"Changes in federal funding levels are shifting the burden for water quality to the state, city, and community levels," notes Eugene Cronin, an expert on estuaries—especially the Chesapeake Bay—and a 1938 graduate of Western Maryland College. "As federal money is phased out, it's up to communities and even individuals to support pollution controls."

The sandboxes in a northern Ohio laboratory aren't toys, but part of a project designed to explain groundwater movement. Scientists at Case Western Reserve University painstakingly reproduce aquifers in miniature to study how water migrates. Gerald Matisoff's models simulate natural conditions by using dyed water for streams, lagoons, and wells. There are discharge areas, where groundwater rises to the surface, and recharge areas, where rain and runoff percolate down to replenish supplies.

Groundwater doesn't exist in vast subterranean rivers; it's found in pools trapped between bedrock walls, or in the spaces between gravel. Other rocks and soil soak up water like a sponge. Groundwater moves slowly, typically a few feet per year, but as fast as a few feet per day. It tends to move down-gradient, or downhill. Its movement is affected by the type of rock comprising the aquifer; water moves quickly through loosely packed layers of rock, slowly through more impermeable ones. Shallow, unconfined aquifers are more vulnerable to contamination than are deep ones protected by overlying layers of rock.

Knowing all that, geologists like Matisoff can make educated guesses about the movement of contaminants through water. But Matisoff wants to do more than guess. He wants to quantify movement, to be able to predict how and how long contaminants will flow through aquifers. "The dynamics

CINCINNATI INQUIRER

are fairly complicated," he says. "Surface flow and groundwater flow are connected, and most people try to think of them separately." Because groundwater moves slowly, a well near a contamination source might be safe for decades. Then again, once it's polluted, a well is likely to remain contaminated for hundreds or even thousands of years.

Two million years ago, the Teays River flowed where the Great Miami Aquifer is today. The ancient river, comparable in size to the Mississippi, carved a broad valley out of cliffs of bedrock. The last Ice Age covered the valley with glaciers, and when these receded, a fine-grained till of sand and gravel filled the river basin. Rainwater percolates through topsoil and is trapped in this till. The water seeps down—less than a foot and a half per day—through cracks in the rocks. Below the meadow, the aquifer is 200 feet thick.

That aquifer holds less than 1 percent of the water that flows beneath the entire United States. The U.S. Geological Survey estimates that 50,000 cubic miles of water—more than nine times the five Great Lakes combined—are contained in aquifers, trapped among layers of limestone and clay, sandstone and shale. Most aquifers lie within a half mile of the Earth's surface, their crystalline waters easily accessible.

How much groundwater in the United States is contaminated? That question can keep a gathering of geologists arguing for hours. The best estimate is between 1 and 3 percent. All but a small portion of that can still be used—if not for drinking water, then for irrigation. But contamination is being reported in every state with increasing frequency.

Many everyday activities can pollute groundwater. Change your oil lately? Chances are good that some of it remained on your driveway to be washed away by the next rain. Never changed your oil? What about the herbicide on your tomato plants, the fertilizer on your lawn, even the suds from your last car wash?

Contamination comes primarily from six sources: hazardous waste leaks at factories and deliberate dumping of waste; leaks from underground storage tanks, mainly of gasoline; pesticides and herbicides that travel through topsoil into aquifers; road salt carried by melting snow and rain; fertilizer and agricultural run-off (manure); and urban waste, including landfills, aging septic tanks, and run-off from residential activities (your car's dirty oil).

Granted, all this waste has to go somewhere. But too often, instead of incinerating it or burying it in leakproof landfills, producers of waste just send it somewhere else. Consider:

- The EPA has designated more than 400 sites like Chem-Dyne "top priority" for Superfund money set aside to clean up hazardous waste dumps. Of all the problems resulting from these dumps, the EPA ranks groundwater contamination as the most serious.
- About 50 to 60 pesticides, many of them carcinogens, have been detected in the groundwater of 30 states surveyed so far, according to the EPA.
- In New Jersey, where more than half the population depends on wells for drinking water, industrial and chemical manufacturers have so polluted the groundwater that nearly 2,000 wells have had to be closed in the last five years.

The Water Gap

It isn't oil, but Kansas exports it. It isn't produce, but California farmers plan to sell it to trendy L.A. residents. It isn't gold, but those who don't have any are willing to pay fantastic sums for it.

It's water. "Water is the most undervalued commodity in the United States," says Quincalee Brown, director of the Water Pollution Control Federation in Washington, D.C. "It could very well be the next oil crisis."

Americans use more than 500 billion gallons of water per day. Between 1980 and 1985, usage from public systems increased by 7 percent. As a result, the price of water is going up. Rates have increased an average of 10 percent during this same period in 120 major cities recently surveyed by Arthur Young and Company.

In some areas, like arid Arizona, the laws of supply and demand are responsible for the price hikes. In others, like Boston, the cost of treating waste water skyrockets as federal subsidies end and utility companies pass increases along to consumers. In New York City, rates jumped 34 percent over the last two years. Boston, saddled with some of the worst water pollution problems in the country, expects to quadruple the average water bill in the next decade. Water costs will rise in small towns as well as big cities as they search farther and farther away for new sources.

"Conservation is going to get more attention," says Don Fries, an engineering student at Villanova University and an administrative assistant at the Perkasie Borough Authority in Pennsylvania. "We're going to have to limit our use. Most people in this country don't realize the problem we're headed for—it's so convenient to turn on the faucet."

If all the water on Earth could be poured into 16 cups, 15 1/2 cups of it would be too salty to drink. Pour out from that 1/2 cup the water that is undrinkable because it's frozen in polar ice caps, polluted, or too hard to reach, and you'd be left with less than a teaspoon.

"All the water we have now is all we're ever going to get," says Gordon Wolman, chair of geography and environmental engineering at Johns Hopkins. "Eventually, that is going to sink in. People are going to realize we have to protect what we have left."

That realization may take a few years, Wolman adds, because we still pay far less for water than for other necessities. A gallon of water, in general, costs much less than a gallon of milk or gasoline. Until the true expense of water is passed along to consumers, conservation efforts may lag.

In Perkasie Borough, as in a growing number of communities, conservation is stressed with a network of laws: a drought contingency plan, mandated water-saving facilities in new houses, and regulations that become more stringent as new technologies make that possible.

The cost of water for cities in the West traditionally has been high. In Arizona, where most drinking water comes from underground aquifers, residents annually use 2.5 million acre-feet more than is returned to the ground by rainfall. (An acre-foot of water would flood an acre of land one foot deep.)

In California, where farmers receive cheap water from state and federal projects at subsidized rates, thirsty L.A. residents are bargaining for the right to buy the water they don't use. Southern Californians typically pay $230 an acre-foot; a farmer may pay as little as $10.

States that find themselves with more water than they use have discovered a sudden cash bonanza; Kansas, for example, exports 10 million acre-feet per year.

Brown speaks regularly to groups about the importance of conservation and education. "I try to make them think," she says. "We all have a lot at stake."

- Industries produce tens of thousands of synthetic chemicals every year, yet the EPA has established maximum contaminant levels for only 30 chemicals so far. These levels are the only standards for drinking water that are enforceable by the federal government.
- Overdevelopment along the East Coast has mined groundwater supplies (by withdrawing water faster than nature can replenish it) so extensively that salt water has begun to intrude into aquifers, contaminating the water.
- Groundwater around all 16 federal nuclear weapons production facilities is polluted with toxic or radioactive wastes, according to the Department of Energy. Cleanup may cost more than $30 billion.

As serious as the problems are, groundwater contamination received little attention until recently. When the topic is water, the focus is usually on acid rain or fouled beaches or dirty harbors. "You can see an oil spill," says civil engineer Lee Christensen, a professor at Villanova University. "You can see sewage when it washes up on our beaches. You can't see groundwater. So it's been ignored."

No longer, he adds, as he tallies the enrollment figures for his courses on environmental and geotechnical engineering. Increasingly, engineers are returning to the classroom to learn about groundwater—how to protect it, how to clean it up. "Groundwater," Christensen says, "is hot. It's the issue of the '90s."

DOUG GARMON

CINCINNATI INQUIRER

A worker dons protective gear for Chem-Dyne's clean-up. Geologist Gerald Matisoff (above left, with graduate student Joseph Eaker) makes sandbox models to predict the flow of contaminants through groundwater.

Town officials in Barnstable, Massachusetts, started wondering in 1985 if they were poisoning their own wells. Barnstable was using its aquifer as its sole water supply—for everything from lemonade and laundry to irrigation. But it was also using it as a wastewater disposal sink. As population crowded the Cape Cod town, wastewater—more than a million gallons per day—increasingly found its way through sand to the aquifer. Although the sand acted as a natural filter, officials suspected a plume of sewage-generated nitrates was traveling toward nearby well fields.

They hired a consulting firm, Whitman & Howard, to study the problem. The firm brought in Frederick Hart, a civil engineer at Worcester Polytechnic Institute, who used a computer to give the city an answer to its pollution problem.

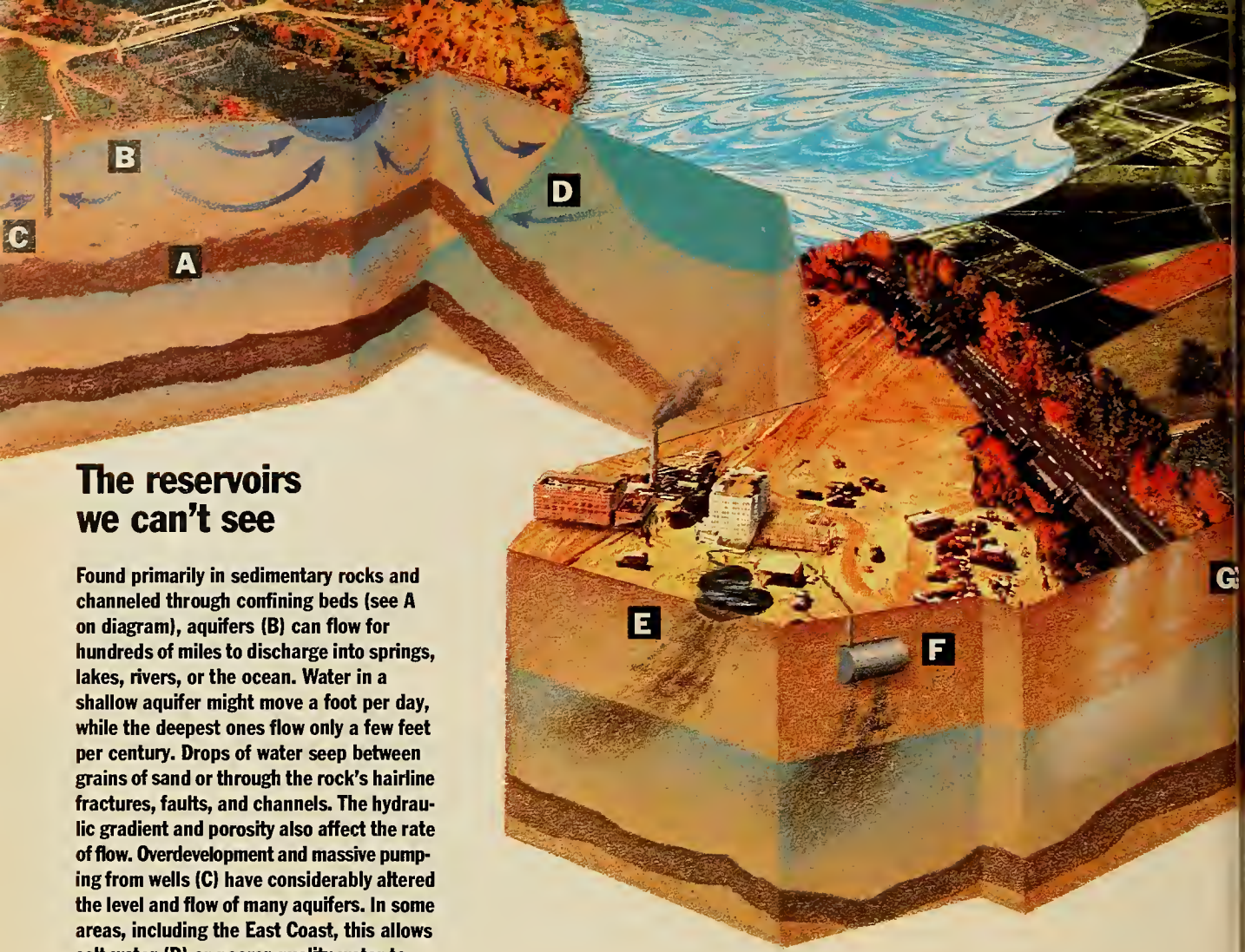
Hart created a three-dimensional contour map of the local water table. Bumps in the map pinpointed the plume's location, while dimples indicated wells. Projections based on population figures and discharge data allowed Hart to predict where the plume would go. Preliminary data showed it was heading south and southeast, potentially affecting several municipal wells. As a result, the consultant recommended building sewers to reroute some of the effluent. They also suggested Barnstable treat its wastewater more extensively unless the town was willing to gamble with disaster.

Computer modeling has become a popular method for observing the invisible underground world of aquifers. The models enable geologists and engineers to evaluate an aquifer's vulnerability or "pollution potential," as the jargon goes. Scientists create the models by gleaning information about groundwater migration from tools like Matisoff's sandboxes.

Matisoff himself used a computer model to evaluate the water system of Bainbridge, a town in south central Ohio. Officials had a list of questions: How much groundwater did they have? How clean was it? And most important, how would development affect water quality? They didn't want to take the future for granted.

Matisoff considered several factors—determined through previous field studies—in preparing a computer model: the depth of the aquifer; the areas and amount of recharge; the aquifer's composition; the soil's composition; the topography or slope of the area; the impact contamination would have on the vadose zone (an airy layer between the aquifer and the surface); and the conductivity of the aquifer. Those characteristics form the acronym DRASTIC.

Matisoff wasn't the first scientist to use a DRASTIC map; the EPA is encouraging states to incorporate them in groundwater studies. Traditionally, cities have had little to say about groundwater until after it is polluted. After all, most industries produce wastes, and they have only a limited number of ways to dispose of them. Incineration is one solution, but many communities reject the furnaces because of concerns about air pollution. As a result, much waste goes to landfills, or is injected into abandoned wells. DRASTIC maps now enable



The reservoirs we can't see

Found primarily in sedimentary rocks and channeled through confining beds (see A on diagram), aquifers (B) can flow for hundreds of miles to discharge into springs, lakes, rivers, or the ocean. Water in a shallow aquifer might move a foot per day, while the deepest ones flow only a few feet per century. Drops of water seep between grains of sand or through the rock's hairline fractures, faults, and channels. The hydraulic gradient and porosity also affect the rate of flow. Overdevelopment and massive pumping from wells (C) have considerably altered the level and flow of many aquifers. In some areas, including the East Coast, this allows salt water (D) or poorer quality water to mingle with pure reserves.

city planners debating sites for a new landfill to avoid sensitive recharge areas. The maps also suggest to city leaders the locations where injection wells might contaminate an aquifer.

The computer models can be helpful in routing hazardous loads around cities, in suggesting emergency responses to chemical spills, even in planning development.

Every road leading to Hamilton has a sign greeting newcomers: "Welcome to Hamilton! the SAFE capital of the world." The exclamation point is no typo; the city officially added it to its name in 1986 to bolster civic pride. The slogan is taken seriously: Banners draped across factories in North End remind employees "Together we can prevent injury," and "Think safety—your family depends on you."

Hal Shepherd was the first Hamilton city manager ever forced to get a search warrant to enter a local business. He isn't excited about that distinction. Hamilton always enjoyed a good reputation with business, and although Chem-Dyne didn't break that reputation, it bent it. During the controversy, Shepherd says business executives began asking him why he was determined to close a local business that provided jobs for his community's residents.

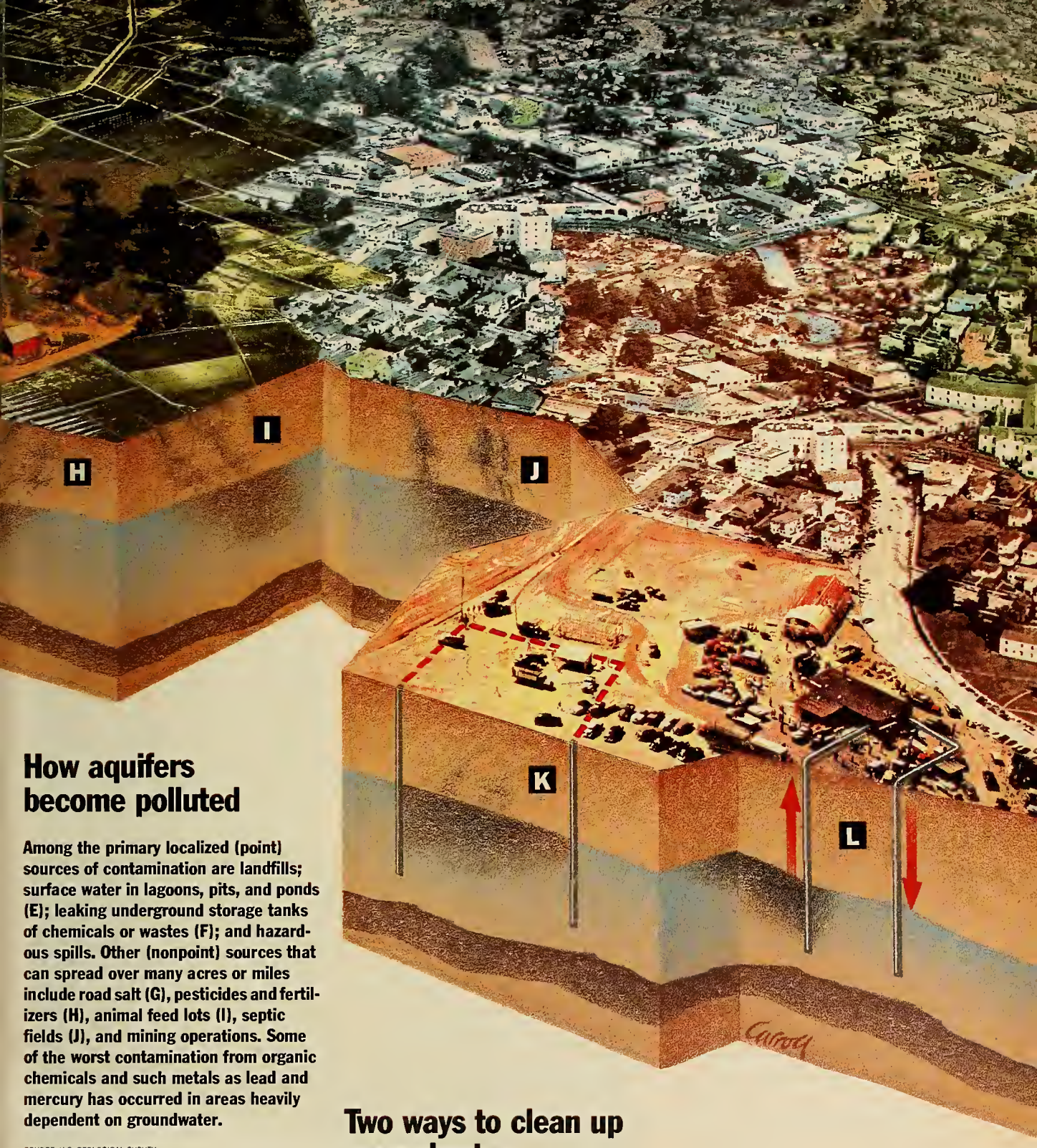
Then there were the newspaper headlines, linking Hamilton day after day with a toxic waste dump. Those didn't help the city's image, either, Shepherd says.

"We didn't lose any business because of Chem-Dyne. But I don't know how many businesses we didn't get because of it," he says. "I just wish we could have closed it sooner. I thought we had the evidence."

Shepherd organized residents into teams to watch the company and report illegal dumping into the Ford Canal. He followed Chem-Dyne trucks to see how much waste came in and how much left. He took photographs of dumping, of leaking drums.

He discovered more than he wanted to know. To recycle pesticides, Chem-Dyne mixed in a little propylene glycol, the main component of antifreeze. Then the company sold the mixture to corporations operating chains of auto repair shops, the EPA said in a later out-of-court settlement. To get rid of PCBs, Chem-Dyne mixed them with oil-based wastes and sold the result as a cheap heating oil. But whenever the mixtures didn't turn out to be marketable, into the gravel pits they went. While company officials were traveling to conventions to promote their "recycling facility," employees were puncturing drums with pickaxes and allowing the contents to seep into the ground, Shepherd says.

"Here we were, trying to shut them down, terrified of what was in there," Shepherd recalls. "And I would go there and see laborers without any protective clothing. They played in the stuff. I'd walk up and they would be splashing unknown



How aquifers become polluted

Among the primary localized (point) sources of contamination are landfills; surface water in lagoons, pits, and ponds (E); leaking underground storage tanks of chemicals or wastes (F); and hazardous spills. Other (nonpoint) sources that can spread over many acres or miles include road salt (G), pesticides and fertilizers (H), animal feed lots (I), septic fields (J), and mining operations. Some of the worst contamination from organic chemicals and such metals as lead and mercury has occurred in areas heavily dependent on groundwater.

SOURCE: U.S. GEOLOGICAL SURVEY

Two ways to clean up groundwater

There is no quick, cheap, or completely effective way to restore the quality of polluted groundwater. One method, containment (K), is used in smaller areas: The goal is to isolate the contaminated water as much as possible by erecting underground barriers or by rerouting its natural channels by pumping. Containment, however, doesn't purify the water. In the second method, extraction (L), the contaminated water is pumped out of the ground, treated to remove toxins, and reinjected into the aquifer. The newest methods under investigation use fungi, bacteria, and microbes to destroy or absorb wastes.

ILLUSTRATION BY ALLEN CARROLL

chemicals on each other."

The Ohio Department of Health released a study in May that found no conclusive link between the high rate of respiratory illness among Hamilton's North End residents and exposure from Chem-Dyne. That comparison of North End's citizens with people living in another part of town showed no real difference between the two groups in the incidence of lung cancer, emphysema, or other respiratory disease. No study has been made of the health impact on Chem-Dyne employees.

Although a growing number of medical experts do attribute some illnesses to contact with polluted water, soil, or air, the link between exposure to toxins and specific illnesses is weak. For example, many pesticides and synthetic chemicals are carcinogens. But so is cigarette smoke. Some chemicals can cause gastrointestinal or liver damage. But so can alcohol.

Because it is hard to prove a direct link between exposure and illness, companies may agree that tainted water isn't healthy but deny that it causes problems like neurological damage, as families in Webster, New York, claimed before reaching a settlement with Xerox.

In 1984 Xerox discovered that 63 pounds of TCE (considered a possible carcinogen by the EPA) had leaked from four underground storage tanks into groundwater. After tests of wells supplying two nearby houses found high concentrations of TCE—more than 60 times New York's recommended limit—the families blamed their neurological problems on the pollution. Xerox denied the connection between contamination and illness, but agreed to buy the houses and relocate the families. Companies like Xerox say they settle because, right or wrong, juries may not listen to their arguments.

Nearly 14,000 people in Fernald, Ohio, living near a federal uranium center, filed a $300 million class-action suit against the federal government after local wells and farmland were found contaminated with uranium. Residents claim the contamination lowered their property values, increased their risk of cancer, and caused them emotional distress. In June a jury sided with the residents. The verdict, however, was nonbinding—the trial was only a form of settlement conference. If the two sides don't settle, they will be back in court this month for a full-fledged trial.

Such cases can indeed drag on. Hamilton officials spent years in court before a settlement could be reached that promised to restore clean water to the Great Miami Aquifer. "I don't worry about Hamilton anymore," Shepherd says. "As long as they clean up the water, I don't think we have anything to worry about. According to the settlement, they have to keep operating those wells until the EPA says the water is clean. Until we say it's clean. And if they finish and a year later, we say the water isn't clean, they have to start up again."

"They" is Chem-Dyne Trust, the group charged with removing the toxins from the water below the 10-acre lot. After Chem-Dyne closed and Kovacs left town, officials for the city, state, and federal government decided to ask the companies that created the wastes to clean up the site. Several agreed, and began removing drums of chemicals for disposal.

But thousands of gallons couldn't be traced directly to any one firm. So, armed with the Resource Conservation and Recovery Act and the new Superfund law, federal and state officials filed suit against Chem-Dyne's customers.

John Boland, the Hopkins professor, sat down with Ohio officials and companies and explained how he determined natural resource damages. He first estimated the cost of getting groundwater from another source if Hamilton's wells became contaminated. He also calculated other costs: loss of land use, treatment for cleaning up the site, preparation of a contingency plan, and damage to the community's image.

"I didn't come up with an exact figure," Boland says. "I thought $5 million was the minimum the companies should pay, and I also thought we could justify as much as $30 million."

After a year of negotiations, the companies settled. Based on Boland's figures, they agreed not only to restore the site but to provide funds up front to protect Hamilton's residents from bearing any of the costs. The settlement was $20 million—and a guarantee that the companies would work together as Chem-Dyne Trust to clean up the groundwater.

Chem-Dyne Trust transported the remaining wastes to approved landfills and incinerators, tore down the buildings, hauled away the contaminated topsoil. It built a fence and hung "No Trespassing" signs. It capped the entire 10 acres with two feet of clay, a synthetic liner, several sand layers, and topsoil. Once the meadow was in place, the trust turned to the problem of the water.

There are few effective methods for cleaning up groundwater—and no cheap ones. Traditionally, engineers have used one of two approaches: containment or extraction. The goal of containment is simple: to keep the polluted water away from the rest of the aquifer, either by building underground barriers or by changing the water's natural flow with pumps. Containment doesn't purify the contaminated water; as a result, it is usually effective only for small areas.

Extraction, known by many as "pump and treat," involves three steps: pumping

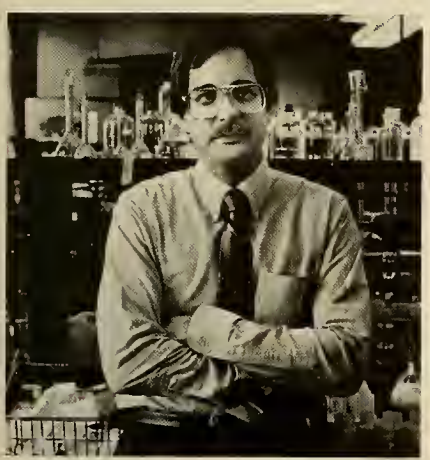
JANET WOODCOCK

the water out of the ground, treating it to remove toxins, and then reinjecting it into the aquifer.

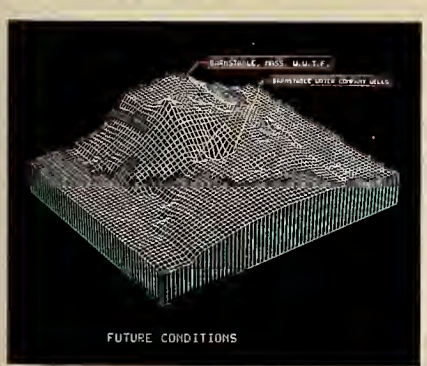
The Chem-Dyne Trust uses both approaches in Hamilton. A ring of 25 extraction wells regulates the flow of contaminated water and provides a continuous supply to surface holders where the water is treated. Other wells are used for reinjection or monitoring.

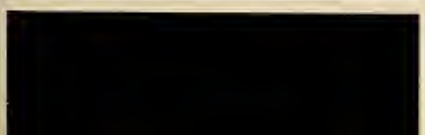
Ron Holt, who vividly remembers his baseball games near the site, is administrative operator at the Chem-Dyne Trust lot today. He has been there since the wells began pumping in 1987. "It's a sealed, continuous system," he explains. "If there were a leak, you'd know it—the smell of the organics is pungent."

More than one million gallons of water are pumped out of the ground every day at Chem-Dyne—nearly 800 gallons a minute. The water is piped to the top of a 44-foot tower. As it falls to the bottom of the sealed tower, it strikes pronged plastic discs that separate it into a fine spray of drops. Volatile chemicals separate from the heavier water during this process, known as air stripping.



Biodegradation is gaining ground as a clean-up method. Edward Bouwer (above) puts bacteria to work to transform toxic chemicals into harmless salts. Computer modeling aids researchers in projecting where problems might occur in the hidden realm of aquifers. Frederick Hart (left) devised a computerized contour map (below) to aid in tracking nitrates threatening wells on Cape Cod.





The water, now stripped, goes into two blue tanks where filters remove iron oxide. Then the water is sent one of two places: either back into the aquifer or into the Ford Canal. Engineers hired by the Chem-Dyne Trust determine how much water must be reinjected back into the aquifer to control the water flow.

With most of the water removed, the chemicals, now in the form of a mist, are pushed through a heater and into a carbon adsorption filter that further separates the particles from steam, which is released into the air.

Once a day, more steam removes the toxic particles clinging to the filters and carries them to another tank, where the gunk settles into a wet sludge. Leftover water is cycled through again. The site produces about 60 pounds of sludge a month, which is shipped to an incinerator to be destroyed.

Monitors regularly test the groundwater, air, and water in the Ford Canal, and provide Chem-Dyne Trust, the city of Hamilton, and the EPA with reports. The process is expected to take at least a decade to complete.

"We don't notice changes day by day, or even month by month," Holt says. "But when they do quarterly tests, we can tell the wells are getting cleaner."

A new method of cleaning groundwater is gaining acceptance among engineers: bioremediation or biodegradation. The unwieldy sounding process involves using nature's smallest animals—fungi, bacteria, and other microbes—to destroy or to absorb wastes. At Hopkins, environmental engineer Edward Bouwer focuses on bacteria that exist naturally in aquifers or the soil above them.

He feeds them a strange diet—a little oxygen-bearing hydrogen peroxide, a little fertilizer filled with nitrogen. Then the bacteria go to work. Nourished by this food, they secrete an enzyme that transforms enormous quantities of such poisons as benzene and trichloroethylene into harmless salts. The trick is to supply enough nitrogen or oxygen to trigger the reaction without polluting the water.

"The goal is to understand the factors that control biodegradation," Bouwer says. "A lot of companies are beginning to advertise that they can clean up a spill with bacteria, but there's a lot we don't know."

At WPI, biologist Pamela Weathers works with fungi that act as a sponge around heavy metals, soaking them up by eating them. She then removes the fungi from the water and coaxes them into giving up the metals, which can be recycled.

Bioremediation works best with synthetic organic substances closely resembling the natural molecules that microbes are used to eating. And combinations of different bacteria—with different appetites, of course—work best on most dumps, because rarely is only one chemical found at a hazardous site. Bouwer and Weathers believe bacteria will eventually be used to clean up hundreds of toxic wastes.

"Ten years ago, the literature said toxic materials were not very degradable," Bouwer says. "Now we're finding they are. In a site over a long time, bacteria evolve that can degrade the waste. Who knows what we'll find in another 10 years?"

Ron Holt figures he'll be at the Chem-Dyne Trust for most of the next decade. But even if he isn't, the cleanup will go on.

"They didn't define clean," he says. "In 10 years, if the EPA decides the water can be a little cleaner, we'll keep right on running. If something else contaminates the water, something not even from Chem-Dyne that shows up here, we'll keep on running. We've got the wells, so as long as they're here, I imagine the government will want to keep using them.

"You have to feel for the companies of Chem-Dyne Trust. I can throw out a McDonald's bag and get a $500 fine. But the man who did this walked away scot-free."

Holt has stopped telling people the name of his employer. "People hear Chem-Dyne Trust, they think Chem-Dyne. They stop listening. They start thinking about all the headlines and pictures in the paper. People don't forget the pictures." He smiles. "These days, I just tell people I'm in hazardous waste management."

Hal Shepherd doesn't think another Chem-Dyne could happen to Hamilton. "There are state laws now we didn't have then. There are local ordinances about the storage and transport of hazardous waste. Once we all started working together, it's been different."

But Holt isn't so sure. "People don't know much about groundwater; it's a whole new ball game. People better learn more about it. They had better get with it." □

There once were 20 limericks that won. . .

Odes t

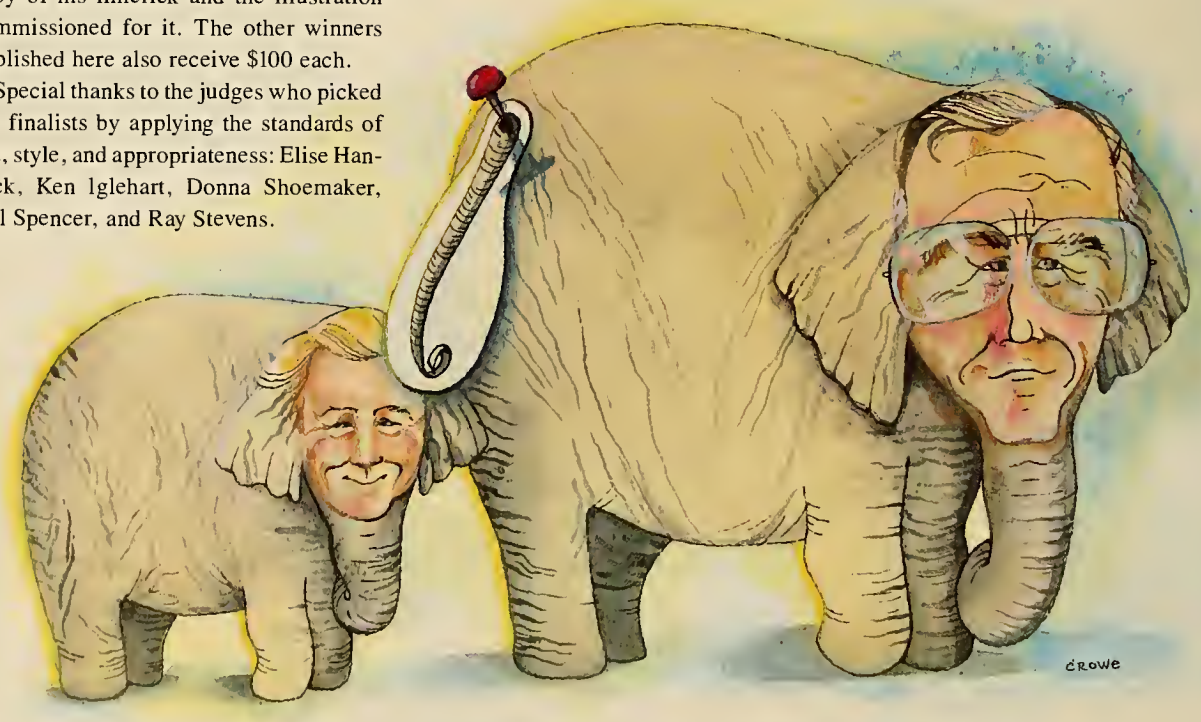
. . . but it's clear *all* the entrants had fun. More than 250 of you mailed, faxed, FedExed, and delivered in person some 827 five-line, rhymed summations of the past decade in response to our competition announced last winter. You could hear our chuckles every time we opened your entries. But we had a tough time winnowing out the winners.

So Isaac Asimov came to the rescue. We asked him to select the one limerick from among the finalists to receive the grand prize. Surprisingly, that limerick aficionado, sci-fi fan, and eminent scientist was stumped. "I've gone through them over and over and I ended with *two*." He added, "One has the cleverest rhymes," but he really liked the other one, too. So we are declaring Maurice Sagoff and Fred Bolotin each a grand winner, and awarding each one $100 and a framed copy of his limerick and the illustration commissioned for it. The other winners published here also receive $100 each.

Special thanks to the judges who picked the finalists by applying the standards of wit, style, and appropriateness: Elise Hancock, Ken Iglehart, Donna Shoemaker, Bill Spencer, and Ray Stevens.

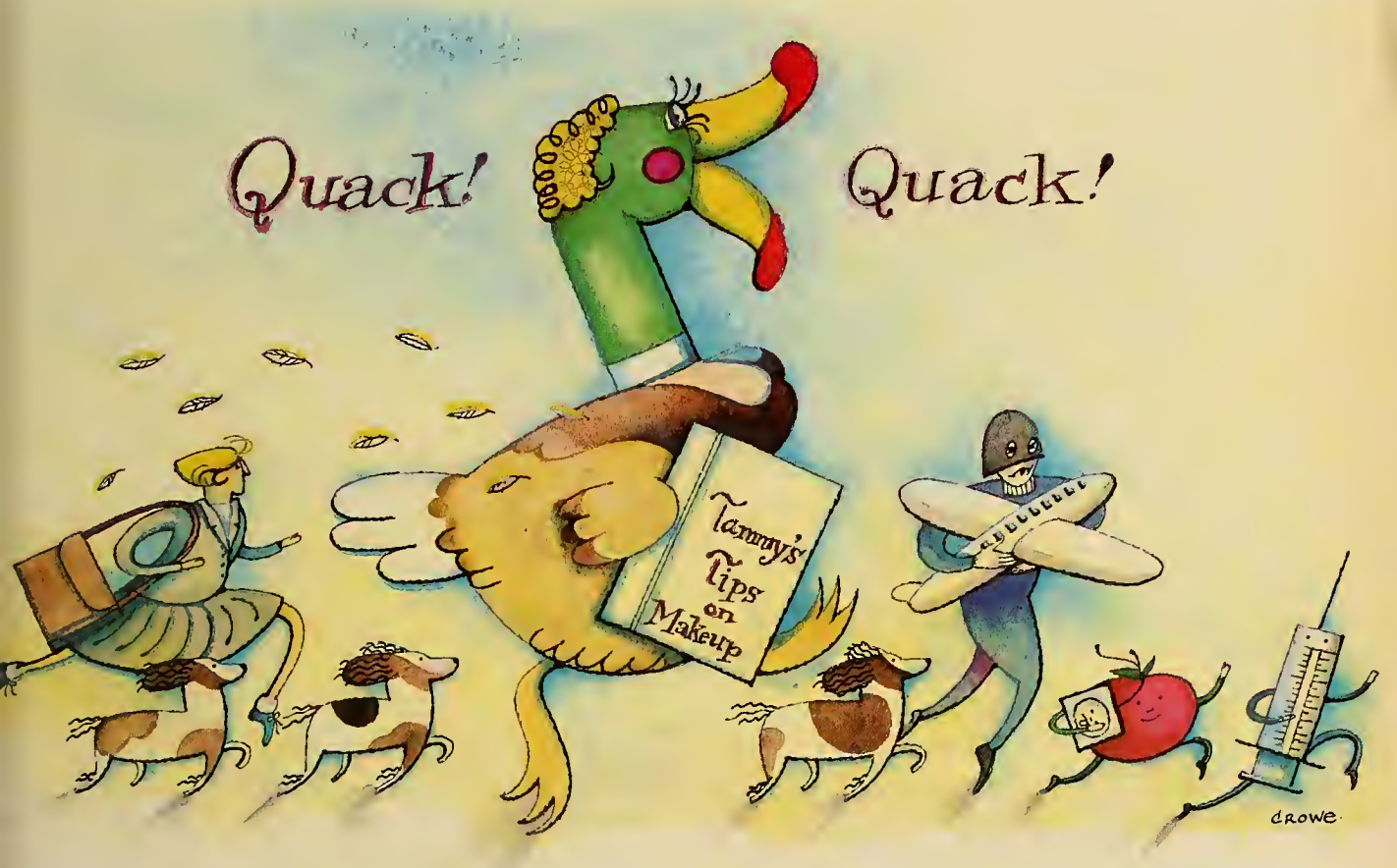
Some Reagan aides wound up in jail,
and Ollie North's now out on bail.
We can't make a push
to pin things on Bush,
for lurking behind is Dan Quayle.

Fred Bolotin
Cleveland, Ohio
Assistant Professor of Political Science
Case Western Reserve University



Illustrations by Trish Dinkel Crowe

the '80s



It was Vanity Fair (not *by Thackeray*)
the Toxics, the Scams, the Highjackery,
the Drugs and the Yuppies,
the First Lady's puppies,
and Televangelical Quackery!

Maurice Sagoff
Acton, Massachusetts

In the '80s, your world is so vast.
With computers, you're moving so fast.
Not a moment to miss,
for while you're reading this,
your future's already your past!

Lawrence F. Farrell
Wayne, Pennsylvania

Limericks as Lessons

Three teachers assigned the limerick contest as a classroom project. Below are some of the dozens of entries sent in from Donna McCubbin Moulton's applied physical science classes at Lake Braddock Secondary School in Burke, Virginia; from Lenora Vizzini's freshman English classes at Gloucester Catholic High School in Gloucester, New Jersey; and from Marjorie R. Hoffman's language arts students at Solomon Schechter Day School in Baltimore.

And a 9-year-old was a winner, too. His mother, Sharon J. Burnham, attached a note with his entry, saying in part: "Our son, Charlie, saw the contest in your magazine *[Johns Hopkins]* and asked if he could enter—when he discovered there was prize money! He was born in 1980, so he felt qualified to write about the decade . . . The enclosed is the limerick he wrote one night while sitting in bed."

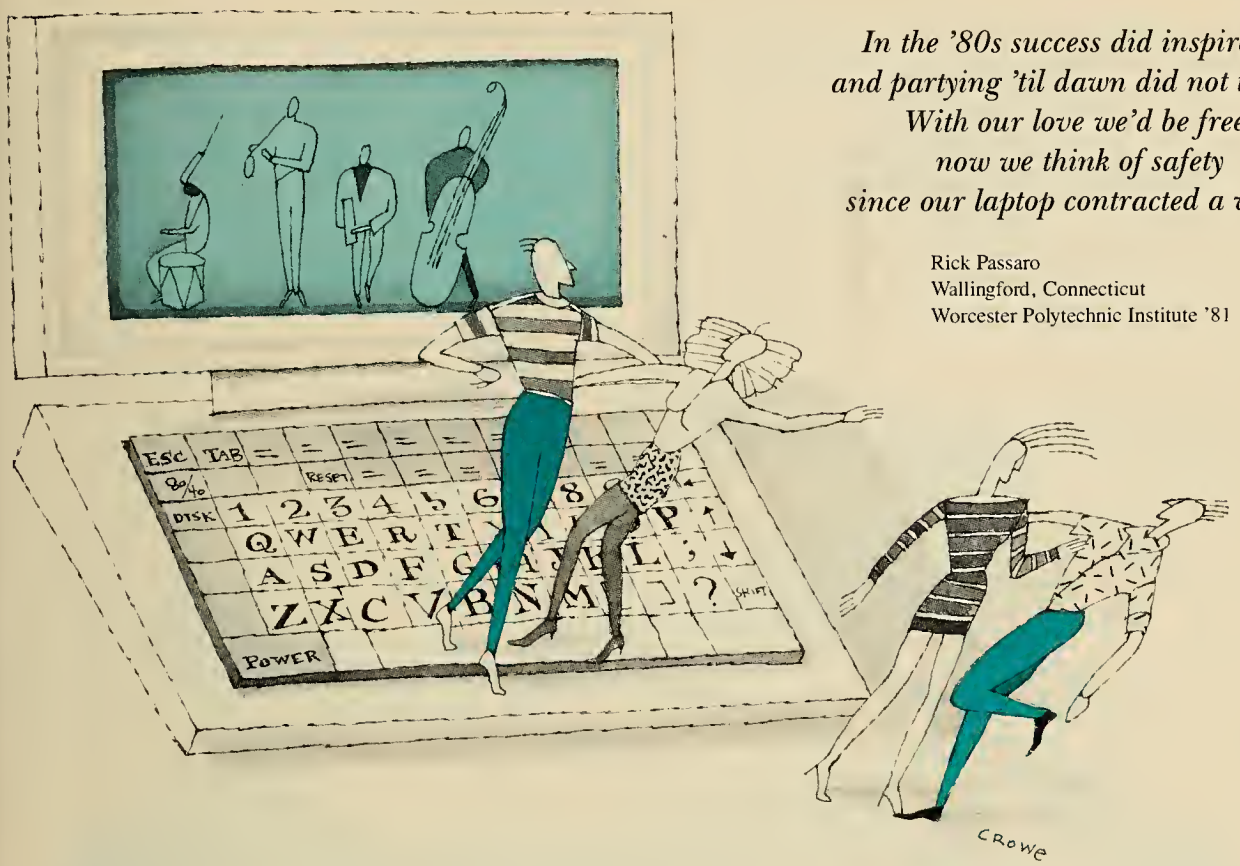
With progress the '80s was filled,
although lots of oil was spilled.
The seas were polluted.
The space shuttle, we renewed it.
And with homeless the country was filled.

Charlie Burnham
Richmond, VA

The '80s Deflaties

The P.T.L. letters are addressed resident.
A man named Dan Quayle is vice president.
We watched the economy inflate,
Olly taught us about Irangate.
They say, "Enter the '90s!" but I'm hesitant.

Spencer Blum
Lake Braddock Secondary School



In the '80s success did inspire us,
and partying 'til dawn did not tire us.
With our love we'd be free,
now we think of safety
since our laptop contracted a virus!

Rick Passaro
Wallingford, Connecticut
Worcester Polytechnic Institute '81

COULD'VE GONE THROUGH THE 80'S WITH EASE

IF THERE WASN'T THAT AWFUL DISEASE

WHERE IT GOES, IT WILL STILL BUT SOME PEOPLE STILL HAVE FREE SEX WITH WHOMEVER THEY PLEASE

It's a shame the young have to see
just how cruel the world seems to be.
So they think there's no hope,
now they're slaves hooked on dope
when at that age they should only be free.

Michelle Pelc
Gloucester Catholic High School

Renee Foschini
Gloucester Catholic High School

In the '90s we have to fight drugs
and robbers and thieves and thugs.
There seems no solution
for ozone pollution.
The world would be better with hugs.

Solomon Schechter Middle School students

In the '60s our causes seemed noble
while the '70s brought interests more global.
In the '80s, I betcha'
the true raison d'être
is to seem to be upwardly mobile.

Carolyn Muhly
Baltimore, Maryland
Western Maryland College '63

In the '80s we all were aware
of the homeless, cocaine, the AIDS scare.
We're relieved that at last
that sad decade has passed
while for more of the same we prepare.

James S. Koch
Euclid, Ohio
Western Reserve College (CLC '52)

Our marriage arrangement's sublime:
Two great jobs, house and cars, hers and mine.
I've quite a commute,
but the salary's a beaut.
We'd have children, but who's got the time?

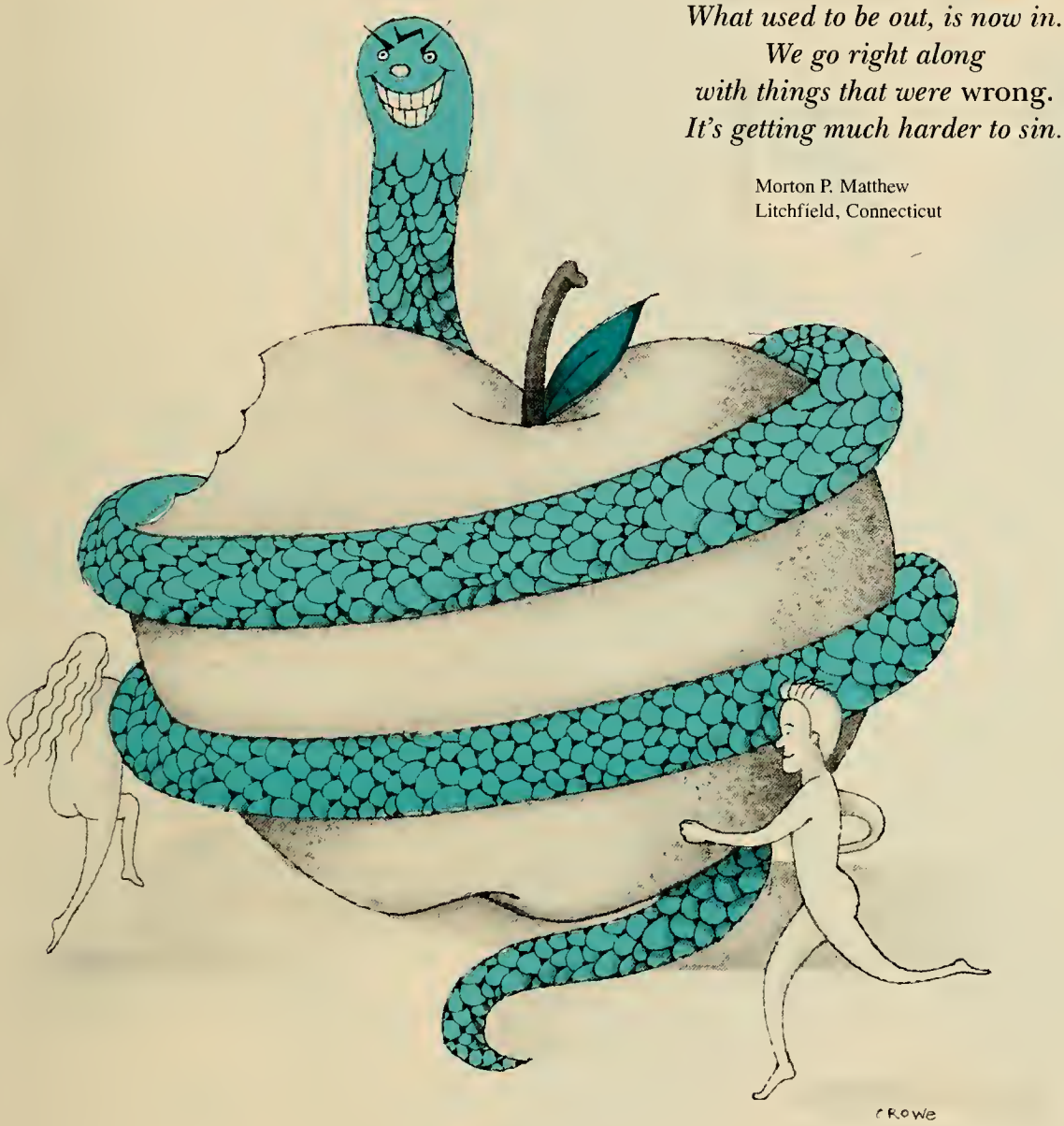
Michael A. Levitas
King of Prussia, Pennsylvania
Johns Hopkins, MD '86

A decadent decade is dimming.
Sex and politics kept its head spinning.
Hart, Tower and North,
Bakers, Swaggart, so forth,
have kept us all groaning and grinning.

Eleanor Lonske
Sudbury, Massachusetts
Worcester Polytechnic Institute, MS '88

It isn't the way it has been:
What used to be out, is now in.
We go right along
with things that were wrong.
It's getting much harder to sin.

Morton P. Matthew
Litchfield, Connecticut



In the '80s the sex revolution
experienced a lot of dilution
as we began to discover
that taking a lover
was a problem and not a solution.

Alan Gordon
Warson Woods, Missouri
Johns Hopkins, BA '55

One decade's the same as the next!
And if you read the biblical text
You then will perceive
that since Adam met Eve
we all have been quite oversexed.

George Malhame
Douglaston, New York
Villanova University (A&S '35)

'Twas an Age when your money was plastic
and our ethical standards elastic.
As the acid rain spilled
on our shores, garbage-filled,
our grand debt grew to totals fantastic.

William J. Murphy
Minersville, Pennsylvania
Villanova University (A&S '30)

The '80s are rapidly ending
with Japanese power ascending.
They mass-produce cars,
microchips, VCRs
while we produce deficit spending.

Eric Bligard
Ford Dodge, Iowa
Johns Hopkins, BA '79, MD '82

They don't lie now, they simply "misspeak."
A betrayal is only a "leak."
And each mess they get in
is explained with a "spin,"
so we're calm as we're sent up the creek.

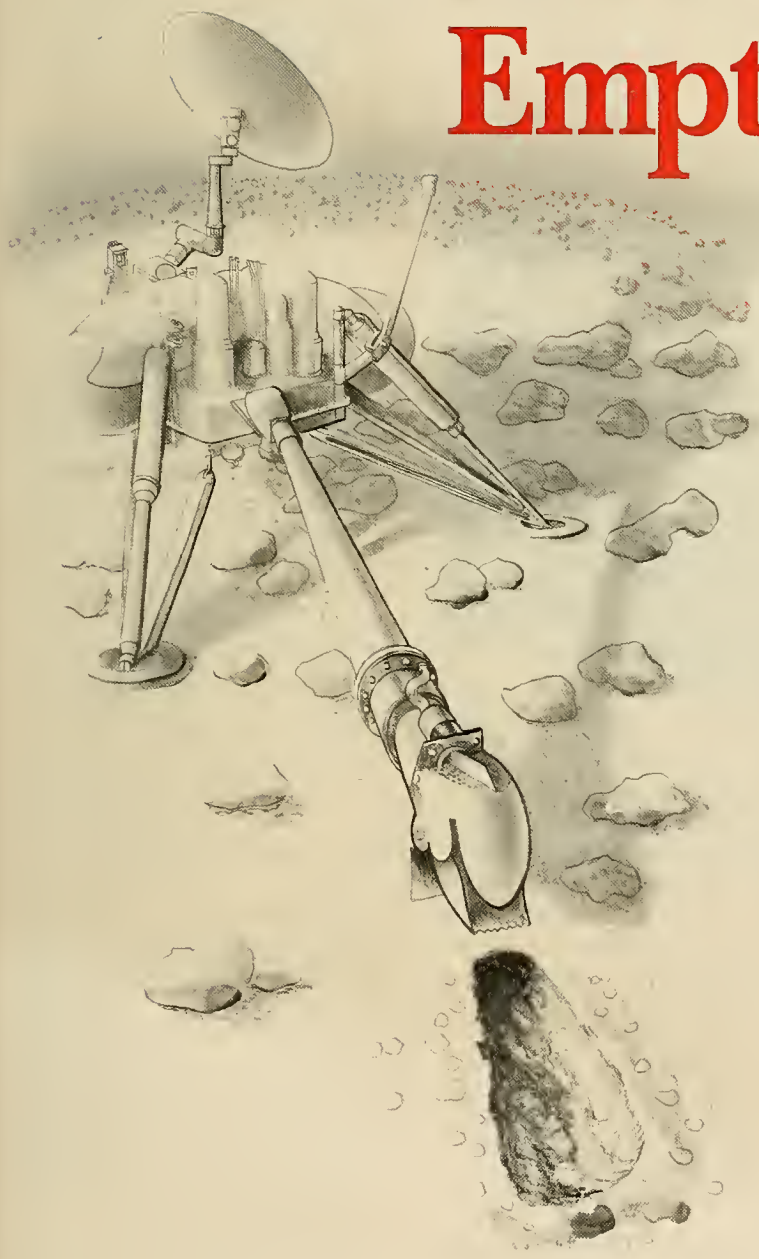
Jean McDevitt
College Park, Maryland

We're chipping away at the ozone.
Our students are in the don't-know zone.
With the stock market yo-yo-ing,
the deficit growing,
we can worry our way to a woe-zone.

Karen Knecht Davis
Etters, Pennsylvania
Western Maryland College '82

CROWE

Message in an Empty Bottle



PAUL METCALF

Suppose you have a bottle filled with an unknown chemical," says Robert C. Plumb, professor of chemistry. "You do some experiments. You put the chemical through various machines and you observe some chemical reactions. But the bottle is empty now. You've used up the chemical and you have to figure out what was in that bottle."

For Plumb, that simple analogy sums up more than a decade of painstaking work he and his students have carried out in his laboratory in Goddard Hall. Year after year, they have searched for the answer to a chemical riddle uncovered by two Viking spacecraft sent to Mars in the mid-1970s to look, among other things, for signs of life on the Red Planet.

Like the chemist in Plumb's analogy, the Viking landers put small samples from the surface of Mars through a few carefully designed experiments. Then the mission was complete. The bottle was empty.

As the results of those experiments streamed back across more than 206 million miles of space, researchers found that, in the best tradition of science, they raised many more questions than they answered. At first hinting of Martian life, in the end the results painted a portrait of a seemingly lifeless planet, but one with a puzzling chemistry. Over the course of the next several years, scientists worked to explain that chemistry, but with limited success. All except one team.

Thirteen years after the Martian enigma first challenged scientists, Plumb and his students have produced the first complete

solution to the puzzle. During those years, 11 others assisted Plumb in his search, and three co-authored with him a paper describing their chemical model; the paper was published this past spring in the prestigious British science journal *Nature*.

The first Viking lander touched down on Mars on July 20, 1976, just two weeks after the U.S. Bicentennial; the other landed a short time later. Eight days after settling onto the Red Planet, each lander stretched out its mechanical arm and scooped up a handful of the Martian regolith. (Plumb avoids the word "soil" when he talks about the material that blankets the Martian surface. Soil, he says, denotes something with the ability to support life. He refers instead to "regolith," the layer of loose material overlying a planet's bedrock.)

JANET WOODCOCK

More than 200,000,000 miles from Earth, Mars is an inhospitable place, Robert Plumb's analysis shows. Its regolith is "pretty nasty stuff," he says, as if a stockroom of chemicals had been mixed together at random.

Like a baker sifting flour, the robot arm gently shook the fine-grained material into test chambers on the landing craft, setting in motion some of the most closely watched experiments in the history of science.

The first chamber into which the regolith fell contained an apparatus known as the labeled-release (LR) experiment. The experiment was designed to detect the presence of anything in the Martian regolith capable of converting organic nutrients into carbon gases, much as aerobic life forms on Earth do when they metabolize food. The test instrument injected a nutrient solution labeled with radioactive carbon into the sample and then looked for the presence of radio-labeled carbon monoxide and carbon dioxide.

In a manner suggesting that metabolism was indeed taking place, the regolith gave off carbon-based gases after the first injection. Regolith that was first heated to kill off any microbes gave off no labeled gases at all. But when the unheated regolith was reinjected with a second dose of nutrients seven days after the first injection, the amount of carbon gases in the last test chamber actually decreased—suggesting that the carbon gases were being reabsorbed. Clearly, if there were organisms in the Martian regolith, they did not behave like Earth creatures.

The second chamber into which the regolith fell contained the gas-exchange experiment or GEX. The GEX humidified the sample and then injected it with a nutrient solution. A test instrument then measured the amount of oxygen produced by the regolith. The regolith gave off much more oxygen than would have been expected due simply to biological activity; when the sample was heated, oxygen was still generated, but in reduced amounts. Again, the evidence pointed to a chemical reaction—perhaps one involving a chemical oxidant—rather than life.

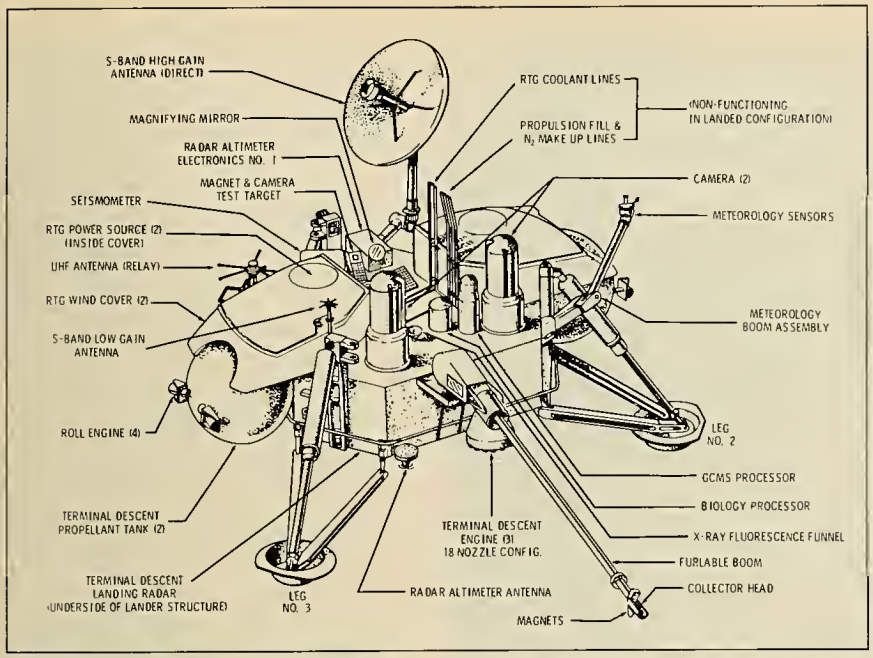
A third device, the pyrolytic-release or carbon assimilation experiment, was designed to see if the Martian regolith, or perhaps any microbes in it, would convert carbon in the atmosphere into organic matter, much as plants and other photosynthetic organisms do on Earth. The results were inconclusive—it is believed that the experiment may not have worked correctly, so the WPI team chose not to address its results in their model.

Martian chemistry was largely unknown before the Viking landers visited the planet, a fact that made things extremely difficult for chemists trying to explain the results of the Viking biology experiments. Plumb suggests that the chemists' work would have been made much simpler—and less error-prone—if the landers had been designed to look for biologically important chemical species such as nitrates, or if they had tested such basic chemical parameters as pH and oxidation states. Why didn't Viking perform such simple tests? The limited space on the landers is an obvious answer, but Plumb believes the funding process itself was partly to blame.

"If you were to go to Congress and ask for a billion dollars to either measure the pH of Martian regolith," Plumb says, "or to see if there is life on Mars, which project do you suppose would get funded? Scientifically it would be helpful to first know what the chemical constraints on life are, but you'd get more headlines for your billion dollars if you go ahead and do the biological experiments."

The Viking landers did have some chemical test equipment. For example, Viking gathered basic information on the elemental composition of the Martian atmosphere and regolith by mass spectroscopy and X-ray fluorescence spectroscopy. While the chemical compounds in the Martian atmosphere are relatively simple, as they are on Earth, such is not the case with compounds in the regolith.

Complex compounds are difficult to piece together solely from information about the elements present, so data on



The two Viking landers were well equipped to study and photograph many aspects of the Martian environment.

oxidation states—the combining forms of elements that provide clues as to which chemical compounds are present—would have been extremely helpful, Plumb says. The lack of such data forced chemists to make largely uninformed guesses when deciphering the results of the biological experiments.

Some biologists hastened to point out that some aspects of the results—the radio-labeled gases evolved during the LR experiment and the absence of such gases when the regolith was preheated before the experiment—did suggest the presence of life. But, Plumb points out, the LR experiment also did something that was not easily explained by life scientists.

"Say you were to feed some microbes," Plumb says, "and, as expected, they gave off radio-labeled carbon gases. When the production of gases slowed down, you might say, 'Give them some more to eat.' When they did that in the LR experiment, the regolith didn't give off more carbon. Instead, the radioactive signal decreased, which was not at all consistent with a biological process."

The gas-exchange experiment provided another argument against biological activity. To chemists, the sudden outpouring of oxygen after the nutrient solution was injected and the lack of an oxygen release after the regolith was heat-treated suggested the presence of an oxidant—a compound that might also explain results of the LR experiment.

Plumb first became involved in the Viking work through the late James Danielli, then head of WPI's Biology Department. Danielli had helped plan the Viking biology experiments, and after the first landing in 1976, he asked Plumb to help interpret the results. "First we had to determine what the returning signals meant," Plumb recounts, "and then theorize the chemical events that might explain those signals."

There was little hesitation in the scientific community to begin speculating immediately about those chemical events. "There were a lot of hypotheses being put forth, and we immediately recognized the fallacies in some of them," Plumb recalls. "People were putting forward theories that were inconsistent with what is known about the Mars environment."

These early chemical models did not have the benefit of support from laboratory simulations. The WPI team, on the other hand, headed straight to the lab to test its early hypotheses (see story, page 33). In 1982, five years into their quest and with several abandoned theories behind them, Plumb's team picked up a promising track. "I said, 'Let's suppose there are nitrates on Mars,'" Plumb remembers. "Nobody knew for sure if there were nitrates there, but you could make a case for it. And then we discovered that with the nitrates we could get the oxygen that was evolved in the gas-exchange experiment."

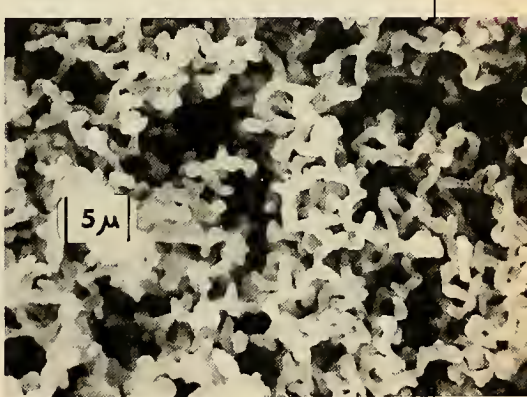
Soviet researchers had suggested early on that some compounds present on the surface of Mars might, upon exposure to radiation, have generated carbon dioxide and oxygen that would become trapped in

Martian Research Spins Off New Chemistry

To develop their model of the Viking biology experiments, Robert Plumb and his research team had to rely on completely new chemistry. For example, the presence of peroxonitrites in irradiated nitrates was not discovered until 1983, when Plumb's team used ultraviolet light to simulate conditions found on the Martian surface.

Another novel finding made by the WPI team, this one with potential significance for industry, was the effect of temperature cycling on certain ternary metal sulfates—three-way compounds of sulfates, metals and water. The discovery stemmed from the knowledge that Martian days can be 60 to 80 degrees C (about 110 to 145 degrees F) warmer during the day than at night.

In an effort to create a simulated Martian soil, Plumb's group subjected magnesium sulfate tetrahydrate to repeated heating and cooling. The cycling caused the chemical crystals to fluff up into a snowy powder. Under a microscope, the crystals, which normally look like rocks, took on the appearance of coral.



As they fluffed up, the crystals greatly increased in surface area and porosity. "We thought originally that the crystals might serve as previously unknown catalysts on the surface of Mars," Plumb says. But while the crystals did not provide an answer to the Martian puzzle, the heat cycling process Plumb created may contribute to fine-powder technology—used to create pigments, aerosols and other types of fine-grained powders here on Earth. Plumb has already taken out a patent on the process.

—PS

pores in the regolith, bubbling forth when moistened in the gas exchange experiment. Plumb's team accepted this hypothesis and showed that the compounds in question were, in fact, nitrates.

Mark C. Libby '85, then completing his MQP under Plumb's direction, performed the many trial simulation runs that finally showed that the oxygen generated in the gas-exchange experiment could be produced by nitrates that had been exposed to levels of ultraviolet radiation thought to be common at the Martian surface.

But that still left unanswered the question of how nitrates might be produced on Mars. "The whole concept of the formation of nitrates on Mars was new," Plumb says, but he had to show that it could happen if he were to include nitrates in his model. In work that was important enough to be published separately, Plumb's team showed that one suspected component of the Martian regolith, magnesium sulphate, can trap gaseous oxides of nitrogen from the atmosphere, thereby providing a mechanism through which nitrogen could be transferred from the atmosphere to the regolith and, via chemical transformation, become part of nitrates.

With the GEX results explained, Plumb says, "then it became a matter of figuring out the chemistry that produced the carbon in the labeled-release experiment." The WPI team, which included Wen Wen Xu, a graduate student in chemistry, decided that an oxidant or oxidizing agent might be removing hydrogen atoms from the radio-labeled amino acids in the nutrient solution, producing radio-labeled carbon dioxide.

"Wen Wen and I were stuck for a long time about the nature of the oxidant," Plumb relates. Then they came across an article published by a group of Soviet scientists hypothesizing the presence of an oxidant known as peroxonitrite in nitrates irradiated with ultraviolet light.

As an oxidant, peroxonitrite had two

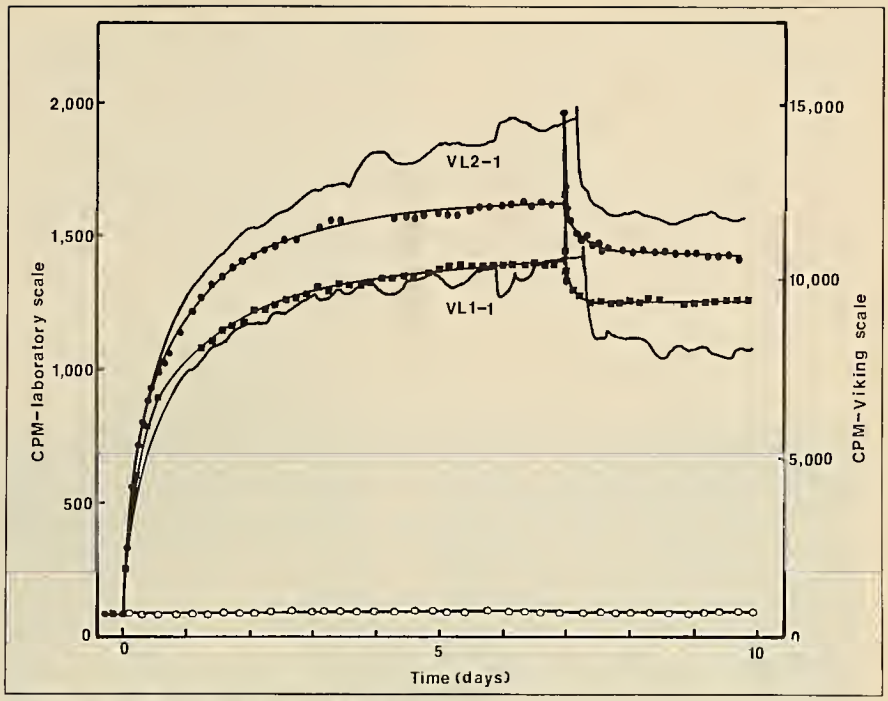
Tools of the trade: Some of the glassware for the test apparatus was made by Plumb (above). A refrigerator is still stocked with samples of the simulated Martian soil (right).

PHOTOS: JANET WOODCOCK

important things going for it, as far as Plumb's group was concerned. First, it seemed reasonable to assume that the compound could be formed under the same conditions—namely, the irradiation of nitrates—that produced the oxygen detected in the GEX experiment. And, peroxonitrite is destroyed by heat, which would explain why no labeled gases were produced in the LR experiment after the regolith was heated. The team immediately set out to see if that chemical could be produced on the Martian surface.

They began their tests with potassium nitrate, which, in previous work, they had shown can exist under Martian conditions. By exposing this compound to the proper levels of ultraviolet light, Libby produced a yellowish powder that, when run through a simulation of the LR experiment, produced results that were breathtakingly similar to those sent back from Mars. Analysis showed that the yellow powder contained peroxonitrite.

Now Plumb's team had a model for the LR experiment: peroxonitrites, when wet with nutrient solution, oxidized the nutrients and generated the carbon-containing gases detected by the experiment. But there



The curves on the top and bottom of this graph show results from the two Viking landers' Labeled Release Experiments. The middle curves show Plumb's results. The sudden dip marks the second nutrient injection and the reabsorption of carbon by calcite. The line at the bottom represents heat-treated soil.

Detours on the Road to an Answer

It is a rare researcher who, faced with uncharted scientific territory, navigates across to a perfect solution without exploring a few dead ends along the way. Robert Plumb and his team traveled down their share of blind alleys as they tracked the answer to the Viking riddle.

"You don't solve problems in chemistry like this anymore," Plumb says. "Now you can analyze compounds and easily determine their composition. But we didn't have any samples of the Martian soil and had to use inductive logic, which can be a slow process."

An early theory held that a decarbonylation reaction was behind the LR results. The idea was that a catalyst such as iron oxide could produce labeled carbon monoxide by removing the CO radical from formate, an organic compound included in the nutrient broth used in the Viking experiments. But simulations showed that the reaction simply would not happen under Martian temperature conditions.

Another sidetrack began when the WPI team discovered alcohol in the nutrient solution used in the actual Viking labeled release (LR) experiment. A NASA contractor had mixed up a large batch of the solution for use in the two landers as well as in follow-up attempts to replicate the results of the LR in the laboratory. Apparently the contractor contaminated the solution with alcohol.

Plumb knew that organic acids, which were included in the nutrient solution, can react with alcohols to form volatile organic compounds known as esters. If generated in significant quantities in the test chamber in the Viking lander, these carbon-based compounds could have appeared to scientists back on Earth to be carbon dioxide produced by microbes feeding on the radio-labeled nutrients.

However, Plumb found that there was too little alcohol in the nutrient solution (0.03 percent by weight) to affect appreciably the LR results. Now that he has published the main part of his Viking work, Plumb plans to publish the alcohol-related work as well.

Iron salts, which can turn organic acids into aldehydes, were also examined as potential culprits. Like esters, aldehydes would have been volatile enough to be picked up as radio-labeled gases by detectors in the LR experiment. Peroxysulfates, the team noted in another hypothesis, might have oxidized the nutrients to produce carbon dioxide. Other oxides, such as those produced by acidic salts, also came under scrutiny.

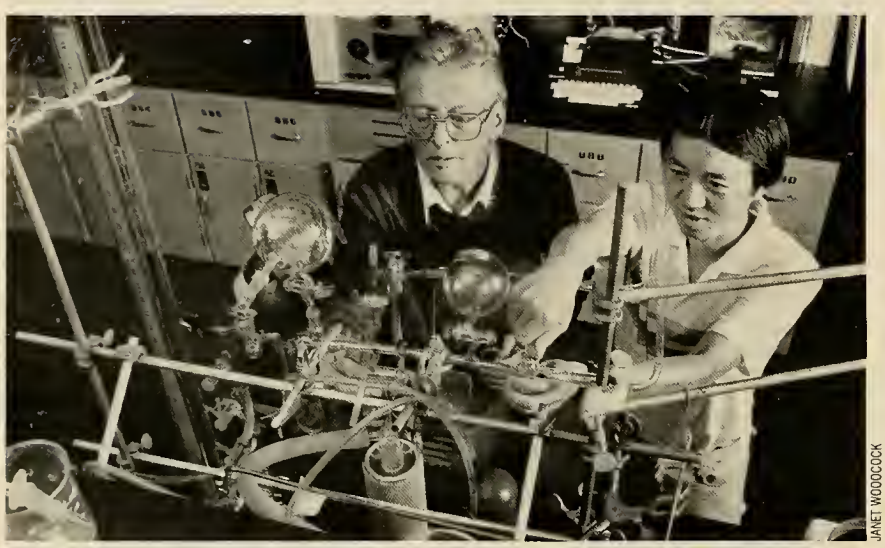
Several of these theories produced encouraging results in LR simulations, but they were, in one way or another, inconsistent with other Viking results or other information about Martian surface conditions.

One hypothesis still widely adhered to by chemists interested in the Viking results is that alkali metal superoxides or hydrogen peroxide, both strong oxidants, produced the LR results. "It's got to be true," says Norman H. Horowitz, professor emeritus of biology at the California Institute of Technology, "because we know that there's water vapor on Mars, and it has to be photolyzed into components that form hydrogen peroxide."

But Plumb notes that superoxides and peroxides are unstable in a carbon dioxide atmosphere such as that on Mars. Furthermore, he points out that no one has been able to demonstrate a comprehensive solution based on the peroxide theory, although several investigators have tried.

was still one important result of the LR experiment that could not be accounted for by the model—the reabsorption of labeled carbon gases following the second injection of nutrient solution. Plumb's theoretical analysis of the chemistry of this phenomenon showed that calcite must be present in the Martian regolith. Thus he and his students used calcite in their experiments and were able to reproduce the reabsorption effect very closely.

In the final analysis, what does Plumb's model reveal about the Martian regolith? "It's pretty nasty stuff," he says. "It's as though you were to go to the stockroom and open up a bunch of containers and mix them together at random."



JANET WOODCOCK

Plumb (left) and graduate student Wen Wen Xu load a sample into apparatus that simulates the Viking Labeled Release Experiment. Plumb insisted that lab tests duplicate conditions on Viking, and Mars, as closely as possible.

Simulating the Viking experiments involved much more than mixing up the suspected components of Martian regolith and subjecting them to standard laboratory analyses. The experiments had to be conducted at conditions of temperature and atmosphere that closely resembled those experienced by the Viking lander. Therefore, a vital part of the research process was the development of the apparatus to do the simulations.

"I think the hardest part was using our Army gas chromatograph (GC)," recalls Libby, who was responsible for experiments to explain the GEX results. "The GC worked, but it was pretty finicky." Another difficulty, Libby says, was measuring the minute amounts of oxygen being generated in a small evacuated container and then feeding the gas into the GC without allowing it to become contaminated with air.

Another of Libby's responsibilities was to process potassium nitrate into potassium nitrite by subjecting it to ultraviolet radiation. He recalls searching in the library for a paper on the nitrate-to-nitrite reaction. "It was a Saturday night about 10 o'clock, and I was about ready to give up," he relates. "I was looking way, way back in the old, old sections of *Transactions of the Faraday Society* and I finally found it."

An unexpected difficulty involved the containers Plumb's team used to simulate the LR experiment. Early experiments were done in glass test tubes, but Plumb decided to switch to stainless steel cells like those actually used in the Viking lander. With the steel cells, the simulations provided the right reactions, but they weren't quantitative—in other words, they weren't generating the expected quantities of products at exactly the right rates. After contacting the TRW engineer who was in charge of building the apparatus used on the Viking lander, and following his exact procedures for polishing and cleaning the containers, the results became quantitative.

For all of the painstaking labor that went into this model, Plumb does not expect his solution to go unchallenged. While the majority of investigators have favored the likelihood of a chemical rather than biological explanation of the results all along, others have maintained that no one had disproved the possibility of a biological solution. After all, Plumb points out, there was a leap of faith involved in saying that the true explanation is chemical and not biological.

But Plumb expects the most strenuous challenges to come from those who contend that valid chemical models have already been proposed that explain each result. Plumb insists, however, that the WPI team's solution is the first to simultaneously explain both the GEX and the LR results, and to do so quantitatively, while being consistent with all of the known information about the chemical and physical conditions on Mars.

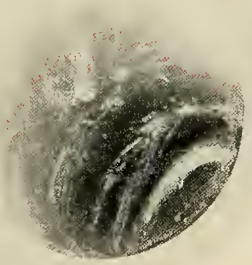
His solution has caught the attention of at least one colleague. Norman H. Horowitz, professor emeritus of biology at the California Institute of Technology in Pasadena, has published a number of papers on his own theory involving peroxides and superoxides. Nevertheless he says he is impressed with Plumb's work.

"The fact that he got results in the lab that were so close to the Viking results—I was startled! I mean, quantitatively his curves are so close to the Viking data that it's just amazing."

Susca is a free-lance writer based in Rindge, N.H.

Probing the Mysteries of Venus

by Ruth Trask



A WPI graduate helps design the Magellan spacecraft that will use sophisticated radar to map the surface of Earth's sister planet.

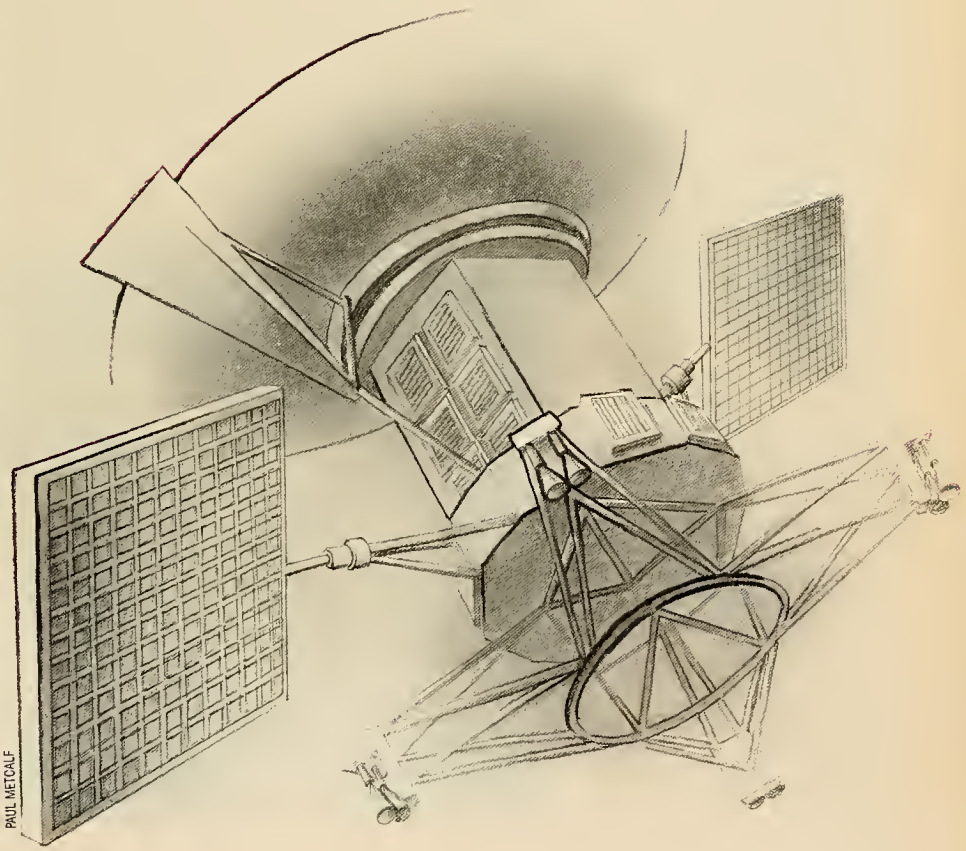
Venus has been called Earth's sister planet. Yet, though the two worlds are very close in size and density, they are very different in other ways. Daytime temperatures on Venus rise to 900 degrees F (hot enough to melt lead), and the pressure at the planet's surface is 90 times that of Earth's.

Scientists have long wondered why Venus and Earth evolved so differently and whether the story of Venus will tell us something about the future of our own planet. But, swathed in thick, swirling clouds of carbon dioxide and sulfuric acid, Venus has not yielded its secrets easily. Spacecraft from the U.S. and the Soviet Union have scanned its surface and even spent brief lifetimes in its harsh atmosphere or on its surface. But much of the mystery of Venus has yet to be unraveled.

This year, a new spacecraft named for Magellan, the 16th-century Portuguese explorer, began a 15-month voyage that will culminate in the most detailed study yet undertaken of Venus. Built by the Martin Marietta Corporation in Colorado, largely of spare parts from other interplanetary spacecraft, Magellan is the first planetary mission sent into space by NASA in more than a decade.

Magellan was launched from the space shuttle Atlantis on May 4, 1989. On its side it bore a plaque inscribed with the names of the scientists, technicians and others who had designed and built it. One of those whose name appeared on that plaque was Scott Mathews, who received his degree in mechanical engineering from WPI in 1982.

Mathews was the first structural engineer to be included in the engineering team that designed and tested Magellan for Martin Marietta. Mathews was first assigned to the Magellan project shortly after joining the company in 1983, when the craft, known then as the Venus Radar Mapper, was still in its early stages of design. After a few months, he was reassigned to another project, but returned to work on Magellan in



PAUL METCALF

1986 and remained with the project through construction and testing.

Magellan began life in the late 1970s as an ambitious platform from which a wide-ranging study of Venus would be made. As NASA began tightening its belt in the early 1980s, the Magellan project's high price tag made it an easy target for cancellation. Later, the project was revived with a much narrower scope. When it reaches Venus, Magellan's primary mission will be to compile a highly detailed, three-dimensional map of 70 to 90 percent of the planet's surface with a sophisticated radar system.

Based on earlier observations, scientists know that Venus is a hot, dry, waterless and probably rocky planet. But little is known about the planet's geological history. Magellan's radar will look for signs of volcanic activity, tectonic processes (moving land masses) and clues that water, perhaps even Venusian seas, may once have existed on the surface.

The spacecraft will also study how the planet radiates heat and how its mass is distributed. Most importantly, researchers hope to learn if the climate of Venus, which seems to be the result of a "greenhouse effect" similar to that caused by the carbon dioxide generated by burning fossil fuels here on Earth, may presage our planet's future.

To answer these questions, Magellan's radar will use a sophisticated system that will reveal details as small as 15 yards across (previously, the most detailed images of the planet showed features no smaller than 60 miles across). Though the radar dish is only 12 feet wide, a computer back on Earth will process the data as if the dish were in fact hundreds of feet in diameter, enabling Magellan to return highly detailed images of the surface.

NASA PHOTO

Often called Earth's sister planet, Venus is a world swathed in mystery.

Mathews and a team of other engineers were responsible for designing a spacecraft that could complete its mission and withstand the rigors of space travel. One of the first challenges that Mathews faced was designing a structure that would both link Magellan to a booster rocket and support the 7,800-pound spacecraft as it sat on the launch pad.

The original design was a truss made from aluminum tubes. But, shortly before Mathews returned to the design team in 1986, the space shuttle Challenger exploded. In the wake of that accident, NASA made numerous changes in its safety rules for cargo carried aboard shuttles. One change created a major challenge for the Martin Marietta engineers.

Magellan was to have been rocketed toward Venus with a Centaur G-Prime booster fueled with liquid hydrogen. But NASA decided to no longer allow the Centaur in the cargo bay because of the volatility of its liquid fuel. To replace the Centaur, the design team chose the Inertial Upper Stage (IUS), a two-stage, solid-fuel rocket built by Boeing Corp.

Unfortunately, the IUS has less thrust than the Centaur, requiring changes to the trajectory of the Magellan probe and necessitating a significant reduction in the weight of the spacecraft. The adapter that Mathews had helped design was reworked as a pin truss made from composite materials. The redesign trimmed about 300 pounds.

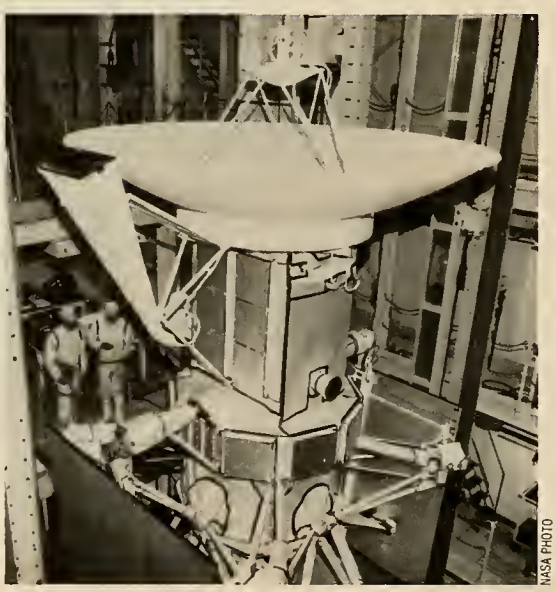
Mathews also designed other elements of the spacecraft's structure. All spacecraft designers must deal with the great temperature extremes of space. Surfaces facing the sun bake, while those in shadow endure extreme cold. To regulate Magellan's temperature, Mathews' team chose to cover it with a reflective and insulating white paint and to attach small mirrors to the main body of the craft to reflect direct sunlight.

In addition to design work, Mathews also completed fracture analyses of the spacecraft to assure NASA that Magellan would not develop catastrophic cracks during its mission. He also created test devices for the project and helped supervise the final assembly and transportation of Magellan to Florida.

After completing his work on Magellan, Mathews was assigned to a team working on the Tethered Satellite Program. A joint project with an Italian aerospace firm, the reusable spherical satellite is designed to conduct research in such areas as atmospheric science and electromechanics. The satellite—attached to the space shuttle cargo bay with a Kevlar tether—can float up to 60 miles away from the spacecraft. Mathews says his next assignment may involve work on a robotic system that will be used to assemble the U.S. space station.

For Mathews, working on space hardware is something of a dream come true. Having grown up during the heyday of the U.S. manned space program, he became fascinated with aviation and space. His first job after graduating from WPI was with Rockwell International, where he helped design military aircraft. After a year he moved on to Martin Marietta, where he felt he could work on a wider variety of projects.

"After I had worked in the aerospace field for a few years it dawned on me that I had found myself, in a way," he says, "that I had found what I had been searching for. That was a very satisfying feeling."



NASA PHOTO

The Magellan spacecraft undergoes testing at Martin Marietta.

INNOVATIONS

Breathing New Life Into Biology

In the future, man may journey to distant stars. Already, scientists are wondering how to build life-support systems that will provide for the needs of astronauts on flights that could last hundreds of years.

Designing such a system was the task given to a group of WPI biology students this year in an innovative new introductory biology course created and taught by Professors Judith Miller and Ronald Cheetham.

When the Department of Biology and Biotechnology decided in 1988 to develop a separate introductory course sequence for its majors, Miller and Cheetham were assigned the job.

"We were rearranging the same old lectures and labs, but stopped about halfway through and said, 'Yuck, this is really boring,'" Miller says. "So we decided to trash the traditional course structure and implement an active learning approach."

There are no lectures in the new course. Instead, students are assigned major problems, such as sustaining life during long space flights. They must solve one, at least in part, by the end of each term.

"We encourage students to brainstorm," Miller says, "to ask questions about what they will have to understand in order to deal with the problem. We help them subdivide those questions into topic areas—like food, waste, atmosphere and reproduction—and then appoint a curriculum committee of students to choose which topics we will deal with."

Without the structure of a traditional lecture-oriented course, do students learn all they need to know to proceed to more advanced courses? Miller and Cheetham say that was the students' major concern.

"Our objectives," she says, "were to get students excited about biology and to have them think of biology as a problem-solving endeavor and not as a catalog of facts to memorize. In a traditional format, students attend large lectures, which they hate, and memorize lots of facts, which they promptly forget. We wanted our students to develop problem-solving skills and, by solving problems, to acquire a substantial body of factual knowledge, which we think they will retain."

JANET WOODCOCK

In an innovative new biology course developed in part by Judith Miller (left), students learn by solving problems, not just memorizing facts.

Most biology majors at WPI have taken one or more biology courses in high school that exposed them to basic principles, Miller notes. "We can better reinforce those principles by putting them to work on real-life problems."

Miller and Cheetham say they also decided to steer away from the traditional when it came to designing labs for the course sequence. Generally, students in introductory science courses complete assigned lab projects with predetermined outcomes and then write lengthy lab reports. In the new course, students complete up to nine lab modules that introduce them to such basic laboratory techniques as microscopy, the use of balances, the preparation of solutions and spectrophotometry. These skills are used during the second term in independent experimental studies.

Miller and Cheetham also used an unconventional approach to grading the course. The class as a whole graded each group's oral presentations. Within each group, students graded their own performances and those of the other group members. These scores accounted for 30 percent of each student's grade, while a full 45 percent of a student's grade was attributable to the performance of his or her group.

"The idea was that the group members should sink or swim together," Cheetham says. "They were dependent on each other. If they had a group member who was having difficulty, then it was up to the group to help bring that person up to speed. In the process, the tutors learned, too."

To see how well the course met its objectives, the professors used a grant from WPI's Educational Development Council to fund an evaluation by Leonard Goodwin, professor of social science and policy studies. Goodwin distributed a questionnaire to students at the beginning and end of the course and conducted group interviews while the course was in progress.

He will compare the success of these students as they move into more advanced biology courses with that of others who took the traditional introductory course during the past two years.

Student reports indicate that most were quite satisfied with the new approach, the two instructors note. While some found it difficult to part with the familiar trappings of the traditional classroom experience, Miller says there was one aspect of the course that was universally embraced.

"No one asked us for a test," she says.

—Michael Dorsey

EXPLORATIONS

Giving Asparagus a Fighting Chance

Major Qualifying Project by Matthew J. Glubiak '89.
Advisors: Ronald D. Cheetham, associate professor, and Pamela J. Weathers, assistant professor of biology and biotechnology.
Sponsor: Nourse Farms, South Deerfield, Mass.

A type of crown rot called *Fusarium* has long plagued asparagus growers because it lowers the productivity of their plants. To compensate for this productivity loss, farmers sow only male plants, which tend to produce more harvestable spears than females. Another alternative, one being pursued in a number of laboratories, is the development of strains of the vegetable that are resistant to *Fusarium*.

One such strain is the male version of an asparagus variety known as Scott Howard. The Scott Howard is a "supermale"—with two "X" chromosomes—which means that all the offspring it produces when crossed with a normal female will be disease-resistant males. Though this variety is resistant to *Fusarium,* it is not easily grown in the field.

Glubiak spent nearly a year developing a way to improve the growth of this male asparagus by using the technique of tissue culture—a method of cloning plants by growing individual cells, or groups of cells, in special solutions of nutrients and hormones. He achieved his best results when he grew the clones in a new type of bioreactor that uses a fine mist—instead of soil or agar—as a growth medium. Called the Mistifier™, the reactor was developed by Profs. Weathers and Cheetham, along with Kenneth Giles, a former member of the Institute's faculty who is now CEO and director of plant research at Vipont Pharmaceuticals of Canada.

"The main difficulty in growing the asparagus is producing enough roots to enable the plantlet to survive transfer to the outside environment," Glubiak notes. "The results clearly show the superiority of growing asparagus in the Mistifier™."

Glubiak says he maximized root growth and increased both the length and the number of shoots by using rock wool on the surface of the chamber floor and by culturing the plantlets in the plant hormone Indole-3-propionic Acid. He recommended that additional experiments with other hormones be undertaken in the future.

Nourse Farms plans to fund additional research at WPI to follow up on Glubiak's work and to find ways to exploit this new approach commercially.

Seeking New Sources of Ethylene

Major Qualifying Project by Mario Lebl '89.
Advisor: Alvin H. Weiss, professor of chemical engineering.

Ethylene is a colorless, flammable gas made from either ethane or naptha. It is used in the production of the widely used polymers polyethylene and vinyl chloride, as well as in the manufacture of many other petroleum products. Considered the world's most important petrochemical—in terms of demand and economic value—ethylene is currently in short supply throughout the world.

At WPI, an international team of researchers has been looking for a simple and inexpensive way to boost the production of ethylene by making the compound from methane, the most abundant hydrocarbon on earth.

With a $50,000 grant from the National Science Foundation, the U.S.A./Bulgaria Research Collaboration in Catalysis, as the team is known, has been conducting experiments in dimerization, a two-step process in which methane is carefully oxidized to ethane. The ethane is then steam-cracked to ethylene.

As a member of the team, Lebl, a native of Sao Paolo, Brazil, helped design and build a quartz-lined stainless steel reactor to operate at very high temperatures and pressures and studied how both ethane and methane reacted to those conditions.

"This provided experimental evidence for the group's hypothesis that the ethane was produced via a catalytic route, and that the ethylene that was observed in the reaction products was produced thermally," Weiss notes.

The other members of the team are

MICHAEL DORSEY

Members of the U.S.A./Bulgaria Research Collaboration in Catalysis: (l to r) Alvin Weiss, Mario Lebl, Nadka Davidova and Paulina Kovacheva.

Paulina Kovacheva and Nadka Davidova, scientists at the Institute of Kinetics and Catalysis of the Bulgarian Academy of Sciences, and Captain Richard A. Holmes, a graduate student in chemical engineering.

"Catalytic processes using methane, the major constituent of natural gas, provide a non petroleum source of petrochemicals, specifically ethylene and its derivatives," Weiss explains.

"Ultimately we hope our experiments will provide the basis for a commercial process, which will lead to conservation of our petroleum resources. While ours are only early experiments, I expect that the process will be perfected and used when petroleum prices escalate in the future, making the process economically feasible."

Using Anencephalic Infants as Organ Donors

Humanities Sufficiency by Christopher J. Buntel '90.
Advisor: Thomas A. Shannon, professor of religion and social ethics.

Anencephalic infants are born with most or all of their brains missing, but with their other organs viable. Buntel examined the ethics of using these infants as organ donors.

Anencephalic infants invariably die within a few days of birth, Buntel notes. If transplantation is not performed, another infant that might have benefitted by receiving donated organs from the anencephalic infant will almost certainly die as well.

"The case in favor of transplantation has two facets," he notes. "First, the long-term view favors one life saved in place of two newborns lost. Second, the transplant gives a meaning to the anencephalic infant's short life.

"The net gain of the operation is the saved life of a person with no additional losses inflicted," he adds. "This gain/loss evaluation clearly indicates transplantation as the only reasonable option."

Buntel's was one of three Humanities Sufficiencies honored this year with WPI's Class of 1879 Award. The other winners were "The Mask: A Window to Understand the Eskimos," by Jeanette M. Cheetham '88, and "American Gas Mask Research during World War II," by Marc J. Champagne '89.

MICHAEL DORSEY

J. Raheem Hosseini (left) and Jennifer Jaramillo hold the polycarbonate material used in their solar still that will help Botswana produce drinkable water.

Bringing Water to the Kgalagadi Desert

Major Qualifying Project by Jennifer L. Jaramillo '89 and J. Raheem Hosseini '89.
Advisor: Mohammad N. Noori, assistant professor of mechanical engineering.

In this age of Jacuzzis®, instant hot water makers and shower massages, it's easy to take the existence of plentiful, clean water for granted.

In many parts of the world, though, water is a scarce commodity. The Kgalagadi Desert in South Africa is one such place. There, native Basarwa and Bakgalagadi people store in ostrich eggs water from dew, roots and the occassional rainfall. They bury the eggs under the sand to save for the drier times of the year. In addition, water is at times trucked into the desert, an expensive undertaking.

Attempts have been made to drill wells in the desert, but invariably the wells produce saltwater. Hosseini and Jaramillo decided to devise a simple and inexpensive way to turn this saltwater into salt-free drinking water.

They designed and tested a simple desalination unit. The still is an example of appropriate technology, they note, since it is simple enough for unskilled people to understand and assemble, low in cost and can be constructed of readily available materials.

Saltwater is placed in a fiberglass basin enclosed by a slanted cover made from structured polycarbonate, a lightweight material that can be easily formed into any shape and has an impact strength 250 times that of glass. Sun shining through the clear plastic evaporates the water, which collects on the plastic and runs down into the collection trough. The still can produce at least 5 liters of drinking water each day.

The estimated cost of each unit is about $250, but the students note that savings should be realized when purchasing and manufacturing arrangements are made. Jaramillo and Hosseini are currently in the process of patenting the device, which won first place in the 1989 Project Night Competition sponsored by the WPI Student Alumni Society.

As part of an earlier project, Hosseini, a resident of Botswana, established his country's first solar photovoltaics company. He is currently negotiating with a major U.S. solar energy company that might manufacture the solar modules used to power the lighting systems he had designed.

—Bonnie Gelbwasser

FINAL WORD

80 Years of "Hamming it Up"

Perhaps no other club in WPI history was greeted with greater student interest at its founding than the WPI Wireless Association. Of 400 students enrolled at the college on October 21, 1909, 56 signed up as charter members. Now celebrating its 80th anniversary, the club still operates the first and oldest college amateur radio station in the country.

Instant long-distance voice communication was still a relatively new phenomenon in 1909. Americans were still getting used to the telephone, which had been around for just a few decades, so the ability to send and receive messages instantly without wires was then considered an amazing advance in technology. In fact, radio was the hottest new topic in electrical engineering.

Within two months of the club's creation, its members were on the air and in contact with other early radio pioneers. By 1913, the federal government established regulations for radio operators and issued the first licenses. The WPI Wireless Association was given the call sign 1YK. Several years later the "W" prefix was added.

"Just about every piece of the early equipment had to be designed and constructed by the students themselves," says Professor Emeritus Donald W. Howe '38. "Early radio was a do-it-yourself challenge since there was no local Radio Shack store to supply parts." Howe, who earned his first amateur radio license as a high school student in 1931, was involved with W1YK through college and has been an advisor to the club since he joined the faculty in 1942.

"A great many of those students who caught the radio 'bug' while keying out Morse code messages from Station W1YK went on to distinguished careers in electronics," notes Howe. "At the risk of omitting many outstanding contributors to the profession, I'll mention just two. Both Chapin Cutler '37 and Harold Black '21 developed many highly significant technological advances during their lifelong careers at Bell Laboratories. I'm proud to have known them both."

Except during World Wars I and II, when the government restricted amateur radio activity for security reasons, W1YK has been a familiar call sign to amateur radio operators throughout the world. Right after World War I, its 50-watt tube station was among the first to be heard across the Atlantic on the 200-meter band.

In the early days of the Wireless Association, students designed and built their own equipment.

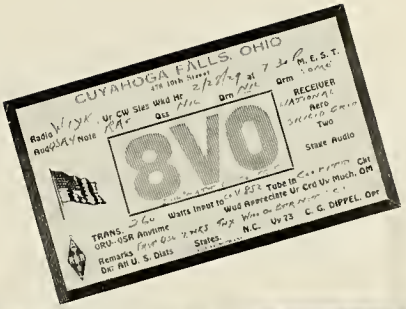
In the early 1920s, research in voice transmission resulted in a transmitter so good that Prof. Harold Maxfield described play-by-play action at WPI basketball games for the benefit of area fans who could tune in on their primitive crystal sets. With the coming of commercial broadcasting that same decade, the Federal Communications Commission restricted such activities by amateur stations and these broadcasts were curtailed.

The club's interests over the years have been educational rather than recreational, says Howe. In the fall of 1931, for example, the club presented a series of classes on the state of research in television. That was eight years before the public first saw TV on display at the 1939 World's Fair in New York.

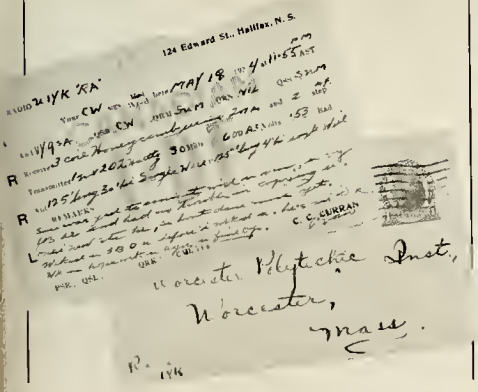
Station W1YK continues to carry the fame of WPI around the globe according to Robert M. Taylor, the current trustee of the station. As trustee, the station license is in his name.

Taylor is principal laboratory technician in the Mechanical Engineering Department and has been on the college staff since 1967. He developed his interest in radio working with the club in his spare time.

"With the ready availability of highly sophisticated electronics, the challenge for the club is no longer to build better pieces of equipment," he says. "Our goal now is



They used these homemade radio sets to talk to fellow hams all over the world, just as students still do today, as the club celebrates its 80th anniversary.



to help people with an interest in amateur radio develop their skills and earn their FCC licenses."

The club this year has 28 members, all of whom are undergraduates with 'ham' licenses, the requirements for membership according to the bylaws. Although technically not eligible to be members, faculty members and graduate students are welcome in the activities of the association.

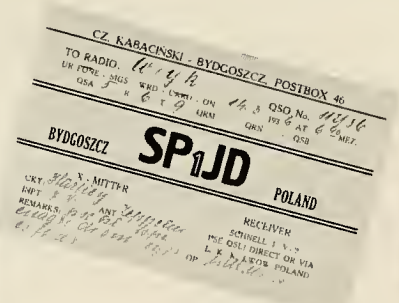
Taylor (call sign NA1Q) and club members teach classes to prepare amateurs for their license exams. As a licensed FCC examiner, Taylor also administers exams for men and women seeking their first or higher licenses.

"With the advent of satellites, we can be in touch with other stations at any spot on earth, or beyond," he says. "Our members have talked with astronauts aboard space shuttles. We've even talked with King Hussein of Jordan, who's an ardent ham operator."

(Note: Recommended reading for those interested in the early days of the WPI Wireless Association is "WPI Wireless Association: Its Origin and Growth, 1909-1921," an Interactive Qualifying Project completed by David M. Mangini '79 and advised by Professors George Stannard and Malcolm Parkinson. It is available at the George C. Gordon Library.)

—Roger N. Perry Jr. '45

Perry is editor of Quest, *the newsletter of the Campaign for Excellence.*



EXCELLENCE IS...

New Equipment for Undergraduate Laboratories

In 1868, when Ichabod Washburn donated the funds for his famous shops at WPI, he knew the technology they contained would help provide students with a state-of-the-art, hands-on education in industrial science. More than 120 years later, WPI is still committed to that objective.

To accomplish its mission now, though, WPI must continually update its undergraduate teaching laboratories. That means maintaining an up-to-date inventory of modern equipment for use in the study of traditional and emerging fields of science and technology.

In recent years WPI has established new laboratories in medical instrumentation, bioprocess engineering and computational mechanics. As new fields emerge in the future, WPI must provide the equipment needed to help teach many of them. To help meet this constant need, several corporations have donated equipment valued at more than $5 million to WPI over the past five years. But there is much more to be done.

Helping WPI purchase needed equipment for undergraduate use, or aiding the college in securing the donation of new equipment, offers alumni, parents and friends an opportunity to participate directly in the *Campaign for Excellence.*

For more than 12 decades, WPI's undergraduate laboratories have served as proving grounds for engineers, scientists, entrepreneurs and managers whose vision and leadership have helped build our modern world. With additional support, in the years ahead WPI graduates can continue to shape the future.

WPI's academic departments have developed working lists of equipment needed to maintain modern laboratories. Please write to the University Relations Office, Equipment Campaign, WPI, 100 Institute Road, Worcester, MA 01609-2280, for department lists in which you are interested.

Support the Campaign for Excellence

WPI Journal

ORCESTER POLYTECHNIC INSTITUTE

FALL 1989

WPI in the World

WPI will observe the 125th anniversary of its founding on May 10, 1990. On that day in 1865 the college received its charter from the Commonwealth of Massachusetts. While a milestone such as this offers an opportunity to remember where WPI has been, it is also a time to look to the challenges that lie ahead.

It is in this spirit that WPI inaugurates its 125th anniversary theme: WPI in the World. The theme will allow us to focus throughout the year on the increasing globalization of technology, manufacturing and commerce; to look at how our alumni and students are faring on this shrinking globe; and to address the role that WPI must play in preparing its students to be citizens of an increasingly interconnected world.

With this theme we also pay tribute to our many alumni who live and work outside the United States; to our international students who add diversity and vitality to WPI's educational programs; and to the many undergraduates who travel around the world to complete projects.

Photo of Venetian canal by Michael J. Kroese '90.

WPI JOURNAL

CONTENTS

VOLUME XCII NO. 4
FALL 1989

Staff of the WPI Journal: Editor, Michael W. Dorsey • Alumni Information Editor, Ruth S. Trask.

Alumni Publications Committee: Samuel Mencow '37, chairman • Paul J. Cleary '71 • James S. Demetry '58 • Judith Donahue, SIM '82 • William J. Firla, Jr. '60 • Carl A. Keyser '39 • Robert C. Labonté '54 • Roger N. Perry Jr. '45.

The WPI Journal (ISSN 0148-6128 is published quarterly for the WPI Alumni Association by Worcester Polytechnic Institute in cooperation with the Alumni Magazine Consortium, with editorial offices at the Johns Hopkins University, Baltimore, MD 21218. Pages I-XVI are published for the Alumni Magazine Consortium [Johns Hopkins University, Villanova University, Western Maryland College, Western Reserve College (Case Western Reserve University), and Worcester Polytechnic Institute] and appear in the respective alumni magazines of those institutions. Second class postage paid at Worcester, MA, and additional mailing offices. Pages 1-12, 29-40 © 1989, Worcester Polytechnic Institute. Pages I-XVI © 1989, Johns Hopkins University.

Staff of the Alumni Magazine Consortium: Editor, Donna Shoemaker • Assistant Editor, Sue De Pasquale • Contributing Wrap Designer, Royce Faddis • Core Designer, Allen Carroll • Typesetter, Jim Wiley.

Advisory Board of the Alumni Magazine Consortium: Johns Hopkins University, Ross Jones and Alan Sea • Villanova University, Eugene J. Ruane and D.M. Howe • Western Maryland College, Joyce Muller and Sherri Kimmel Diegel • Western Reserve College, Victoria Anderson • Worcester Polytechnic Institute, Michael Dorsey.

Acknowledgments: Typesetting, Johns Hopkins University; Printing, American Press Inc.

Diverse views on subjects of public interest are presented in the magazine. These views do not necessarily reflect the opinions of the editors or official policies of WPI. Address correspondence to the Editor, The WPI Journal, Worcester, MA 01609-2280. Telephone (508) 831-5609. Postmaster: If undeliverable, please send form 3579 to the address above. Do not return publication.

4 **A World Apart** *Bonnie Gelbwasser*
Seven weeks at a remote project center can change a student's life.

I **Invisible Evidence** *Sue De Pasquale*
Dusting for DNA fingerprints at the scene of a crime gives detectives the upper hand.

VI **Songs of Autumn** *Jack Wennerstrom*
The season evokes sad, sweet memories.

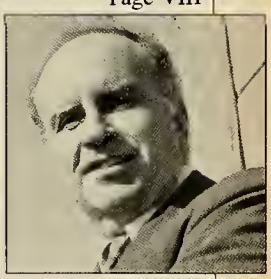
VIII **Generating Energy Options** *Leslie Brunetta*
Cutting down on electricity usage may be the best approach. Plus, 25 ways you can save energy.

29 **Live Wires** *Michael W. Dorsey*
The high-voltage research of WPI's power systems engineering group.

35 **The Oldest Living Graduate** *Ruth Trask*
Still going strong at 104, Sumner Davis '08 has truly had a wonderful life.

Page 4

Page VIII


Page 29

Page 35

DEPARTMENTS

2 **Advance Word:** Becoming a global university. *Michael Dorsey*

37 **Memory Bank:** Those championship seasons. *Roger N. Perry '45*

38 **Explorations:** Superfund solutions, British engineers and alcohol in Ireland. *Bonnie Gelbwasser*

40 **Final Word:** Solar-powered computers in the Himalayas. *Bonnie Gelbwasser*

Cover: The flags represent the home nations of WPI's alumni and students. Each circle begins at the darkened square and proceeds clockwise. Circle 1 is innermost; Circle 5 is outermost. **Circle 1:** United States of America, Afghanistan, Algeria, Argentina, Australia, Austria, Bahamas, Bangladesh, Barbados. **Circle 2:** Belgium, Ethiopia, Brazil, Burma, Canada, Caroline Islands, Peoples Republic of China, Colombia, Costa Rica, Cyprus, Denmark, Ecuador, Egypt. **Circle 3:** El Salvador, England, Bolivia, Fiji Islands, Finland, France, Gambia, Federal Republic of Germany, Ghana, Greece, Grenada, Guatemala, Haiti, Honduras, Hong Kong, Iceland, India. **Circle 4:** Indonesia, Iran, Iraq, Ireland, Israel, Italy, Japan, Jordan, Kenya, Republic of Korea, Kuwait, Lebanon, Liberia, Libya, Malaysia, Mexico, Morocco, Netherlands, Netherlands Antilles, New Zealand, Nigeria. **Circle 5:** Norway, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Saudi Arabia, Scotland, Singapore, Republic of South Africa, Spain, Sri Lanka, Sweden, Switzerland, Syria, Taiwan, Thailand, Trinidad and Tobago, Turkey, United Arab Emirates, Venezuela, Vietnam, Yemen Arab Republic, Yugoslavia. Designed by Michael Sherman. Illustrated by Ted Van Llew.

ADVANCE WORD

Becoming a Global University

"We have learned that we cannot live alone, at peace; that our own well-being is dependent on the well-being of other nations, far away. We have learned that we must live as men, and not as ostriches, nor as dogs in the manger. We have learned to be citizens of the world, members of the human community."
—Franklin D. Roosevelt, Fourth Inaugural Address, January 1945

When FDR spoke those words, the human community was nearing the end of its greatest, most all-encompassing war, a war that wrenched the United States out of a long period of isolation and, overnight, turned it into the world's greatest economic power. In the nearly half century since World War II ended, the United States has come to dominate the fields of science, engineering, manufacturing, commerce and mass culture.

But this newfound economic and technological muscle has bred complacency. After World War II, Europe and Asia rebuilt their economies and began to challenge America's dominance, but American industry and American higher education were slow to react. "Because we were on top of the economic pile," noted Paul A. Allaire '60, president of Xerox Corporation, in a recent talk at WPI, "we assumed it was our birthright."

Today Japan is the world's second largest economic power, and Korea and other Asian nations are rapidly catching up. In a few years, a united Europe will stand as a powerful economic rival for the United States. But in many ways America is poorly prepared to compete in this changing world marketplace.

To many, it seems ironic that 50 years after World War II awakened Americans to the interdependence of all nations, the United States has fallen victim to a new form of isolationism. Today science and technology are becoming international enterprises. With increasing ease, the design, manufacture and marketing of products freely crosses national borders. But despite this "globalization of technology," technological education in the United States has remained decidedly parochial.

While future engineers and scientists in Europe are required to learn other languages and study other cultures, American colleges and universities, for the most part, place little emphasis on the skills and insights new engineers and scientists will need to work in what sociologist Marshall McLuhan once dubbed the "global village."

Several recent reports and conferences have emphasized America's need to broaden the education of its engineers and scientists. "America's preeminence hinges on students' ability to think globally," noted Lou Harris in a recent article in *The College Board Review.* Few engineering colleges have taken this rallying cry to heart more than WPI. Over the past 10 years, WPI students have set out in increasing numbers to conduct their required undergraduate projects through programs and at centers around the world.

The off-campus project program began in 1974 with a highly successful residential center in Washington, D.C., and has since expanded in leaps and bounds—across the nation to San Francisco, across the Atlantic to London and the rest of Europe, and, most recently, around the world to Asia. In the next few years, project programs will be launched in the Soviet Union, South America and the Caribbean (see map on next page).

During the past year, more than 170 students participated in WPI's Global Project Program. About 30 percent of this year's graduating class will have completed a project as part of this program, according to William R. Grogan, dean of undergraduate studies. And that figure could rise as high as 50 percent in the years ahead, as opportunities for off-campus projects increase.

Grogan notes that the Global Project Program has little in common with traditional international exchange programs, in which American college students and those from overseas study on each other's campuses. (WPI does participate in exchange programs with several European institutions, as it has since the early 1970s.)

"The role our students play is more akin to consultants," says Grogan. "They work full time as young professionals for a wide range of corporate, government and professional entities. The WPI project teams have an interactive preparation period before they leave the college and have well-developed project proposals accepted in advance. They are then expected to produce professional work, often with pressing deadlines.

"They tackle issues that would daunt undergraduates confined to the classroom," continues Grogan. "These are experiences that tend to broaden a student's intellectual and social horizons." In addition to performing topnotch work, WPI students abroad must adopt to new cultures and, often, new languages. They face different styles of office management at work, and different interpersonal styles among people out in the field—people with whom they must interact to achieve their goals.

Spending a term at an off-campus project center can hardly fail to change a student's outlook on the world and his or her role in it (see story, page 4). But just as important is the influence—termed "radiation" by Grogan—that these students have on the rest of the WPI community when they return to campus.

"Students talk to their roommates and friends about the experiences they've had and the things they've learned," he explains. "In many cases, the students they talk to have their own stories to tell about their experiences off campus. This exchange of ideas and insights raises the awareness on campus of what's going on in the rest of the world. Already, we're beginning to see how this phenomenon is changing our campus culture."

To further enliven that culture, WPI in 1988 launched the Center for International Studies. The center grew out of a strong interest in cross-cultural issues shared by a critical mass of faculty—some foreign-born and some American. Many had for

Here are the locations of WPI's remote project programs and centers. Other programs have been proposed for Asia, South America and the Caribbean. Residential project centers (in Washington, London and Bangkok, and the future center in Hong Kong) are continuously staffed by WPI faculty while students are in residence. Affiliate faculty members, generally residents of the host nations, advise students at project programs.

Key:

U.S.A.
1. Washington, D.C., Project Center 2. San Francisco Project Program

Europe
3. Stirling, Scotland, Project Program, University of Stirling 4. Limerick, Ireland, Project Program, University of Limerick 5. London Project Center 6. Stockholm Project Program, Royal Institute of Technology 7. Darmstadt, Germany, Project Program, Technical University of Darmstadt (to begin in winter 1990) 8. Munich Project Program, Fachhochschule München 9. Zurich Project Program, Federal Technical Institute 10. Venice Project Program, Italian National Research Council 11. Pushkin, U.S.S.R., Project Program, Leningrad Agricultural Institute (to begin in summer 1990)

Asia
12. Bangkok, Thailand, Project Center 13. Hong Kong Project Program (to begin in winter 1991).

years been advising student projects on topics ranging from development in Third World nations to technology transfer between cultures.

The goal of the center, which is directed by Hossein Hakimmashhadi, a native of Iran and an assistant professor of electrical engineering, is to expand opportunities for international studies at WPI by arranging study groups and lectures, organizing overseas tours and advising student projects.

Currently no other technological university offers students opportunities for international studies that equal, or even approach, those offered by WPI. One reason that WPI has gotten a leg up on its sister institutions, Grogan says, is the WPI Plan. To begin with, under the Plan courses are taught in seven-week terms. This allows students to perform concentrated work on focused projects overseas, yet still maintain academic momentum when they return to campus.

Secondly, WPI's Humanities Sufficiency and its well-respected humanities faculty enable students to learn foreign languages. The college currently offers courses in German and will soon begin teaching Spanish. The nine colleges in the Worcester Consortium for Higher Education offer a wide range of other languages that WPI students may study. Students who want advanced instruction in languages can study abroad through one of WPI's exchange programs.

But the cornerstone of WPI's international efforts is the Interactive Qualifying Project (IQP)—the most distinctive element of the Plan, which requires students to investigate the relationship between science, technology and society. Students often do an extraordinary amount of work to fulfill this degree requirement. (For three recent examples, all completed at remote project centers or programs, see Explorations, page 38.)

WPI is beginning to bring its various international studies efforts together under a common umbrella and is seeking funding to enhance and expand these programs. In addition, the college will begin recognizing students as "International Scholars" if they complete their humanities and social science requirements in international studies and work on their IQPs through the Global Project Program.

"This honor will be a special one," Grogan says, "recognizing students who have dedicated the liberal studies component of their education to preparing themselves to live and work as citizens of the world."

—Michael Dorsey

A World Apart

What do students gain by traveling to WPI's remote project centers? Skills and insights that expand their minds and their horizons.

By Bonnie Gelbwasser

They're easy to spot at the airport—clusters of WPI undergraduates bound for Washington, D.C., or overseas destinations like London, Bangkok and Venice. With their cameras and bulging suitcases, they look like typical vacation-bound travelers, but these college men and women are tourists with a twist. Seeing the sights of a new city is secondary to them; their primary goal is completing a project at one of WPI's remote project centers, where, for seven weeks, they will immerse themselves in intensive research, culminating in a report to a sponsoring agency.

WPI's off-campus project centers and programs are in their 15th year of operation. The first remote center was established in 1974 in Washington, D.C. Since then the Institute has added a project program in San Francisco, a resident center in London and project programs in Germany, Ireland, Italy, Scotland, Sweden and Switzerland. In January 1990 WPI will launch the Bangkok Project Center (see accompanying articles for more on the Italian and Bangkok programs). A program at the Leningrad Agricultural Institute in Pushkin, U.S.S.R., will also begin next year. A Hong Kong project program will begin in the winter of 1991 and planning is under way for centers in Puerto Rico and Ecuador.

"Nearly 30 percent of our students currently elect to complete a project at a remote center or program," says William R. Grogan, dean of undergraduate studies. "The numbers are increasing each year and we have reached the point where it can't help but change the college."

The impact of the remote project center experience is both positive and permanent, say project center directors, project advisors, student participants and representatives of the companies, government agencies and professional organizations that have sponsored WPI projects.

"At the remote centers, students are expected to act like young professionals," Grogan says, "and they do so in every respect: in the way they dress, in their sense of responsibility, in their conversation, in the clarity of their priorities and, above all, in their sense of dedication to getting the job done. Although they lapse back into the 'college mode' when they return to campus, there is a powerful residue left in the way they do things and in their personalities that endures for a long time."

"The students grow about three feet, but it all takes place in the brain," adds Susan Vernon-Gerstenfeld, who directs WPI's project programs in Washington, D.C., and Ireland and has served as a project advisor in Washington. "On campus, students are motivated by external pressures: deadlines, exams and peer pressure. They think, 'I have to do well or I'll fail.' At the centers their motivation is internal—the projects make them catch fire. The work they do is substantial and important to the sponsoring agency. The students are in their offices early and work until closing. Their primary motivation is to get the job done."

Francis C. Lutz, associate dean of undergraduate studies, established the Washington, D.C., Project Center and served as its first resident advisor. He says the off-campus centers offer exceptional opportunities for achieving the goals of the Interactive Qualifying Project (IQP), one of three projects all undergraduates must complete. In the IQP, students explore the intersection of science, technology and society.

"Our primary objective for the IQP is to help students recognize that the way to influence public policy decision-making is to understand that a lot of important issues in the world are not technical issues, but 'people' issues," he says. "We want them to realize that nonengineers often think differently than they do, and we want them to respect the fact that a rational, thoughtful, objective approach to problem solving is the way to win the respect of other people.

"Our other objectives are to foster interpersonal skills, such as cooperation and the ability to work as a group. We want them to learn how to orally present an argument and how to write a final report they can live with and that the sponsoring agency can refer to and use. These are critical skills students can take with them into the workplace."

John B. Scalzi '38 says students who participate in a "social-economic engineering project" not only come to understand the effect of engineering on society, but also learn how society views engineering results. Scalzi is a program director for the National Science Foundation, heading up the Division of Critical Engineering Systems within the foundation's Systems Engineering for Large Structures office. In the fall of 1989 he completed his fifth project with WPI undergraduates at the Washington Project Center.

"Future engineers must be able to cope with and appreciate the complexities of society," says Scalzi. "In the future, society will be more dependent on the results and contributions of engineers in all aspects of life. The need, then, is to be prepared, and I hope students realize the importance of their projects, not only as an end in themselves, but as vehicles for gaining additional experience and knowledge."

The students gain directly and indirectly from the project experience, he says. The direct results include the skills they learn as they complete the project, such as the ability to gather, organize and analyze data

"As the Spanish proverb says, 'He, who would bring home the wealth of the Indies, must carry the wealth of the Indies with him,' so it is in traveling, a man must carry knowledge with him if he would bring home knowledge."
—From The Life of Johnson *by James Boswell*

S.K. PHOTOGRAPHY

From left, Daniel J. Smith '91, Tony M. Yee '91 and James C. Wilkinson '91, who completed a project in London last summer.

JANET WOODCOCK

Students who work at remote project centers develop skills that prove invaluable as they begin careers, notes Francis Lutz.

and, most important, the ability to form judgments, reach conclusions and make recommendations.

The indirect benefits are derived from "students' powers of observation and their willingness to participate in and take advantage of the historical and cultural facilities in the Washington area," he says. "They can observe government at work, and take note of the functions of the various federal agencies and their relationship to the taxpayer—something each of them will be in the future."

Students also learn two other important lessons, says Scalzi. First, as frequently occurs in the real world, regardless of whether or not they enjoy their projects, they must be do them and do them "properly and completely." Second, since society might not always welcome or agree with their conclusions, they must learn to respect the opinions of others.

Jeffrey F. Trask '81 elected to complete his IQP at the Washington Project Center because of his interest in industrial and government relations work. In Washington, Trask was part of a team that completed a report for the National Academy of Engineering (NAE). The report examined the influence of organized labor and government regulation on innovation in the domestic automobile industry and compared the ways in which these factors have an impact on car makers in Germany and Japan.

"After my experience in Washington, there was no question but that I would continue in societal/government work," Trask says. "After graduation I went to work for Chevron's research and engineering branch in California. I developed a system for keeping track of regulatory developments for Chevron—helping them anticipate and respond to changes in regulations. Because of the nature of my work, I maintained a lot of contacts in Washington. Hugh Miller, who was director of the NAE at the time I did my project, helped me make contacts in Washington and has remained a friend."

Trask stayed with Chevron for eight years and is now on leave to attend Georgetown University Law Center in Washington. While he goes to school, he works three days a week at the American Petroleum Institute as an environmental regulatory and legislative analyst.

"You get a real education when you do your project in Washington," he notes. "When I worked on my IQP I dealt with a lot of trade associations, labor organizations and other groups involved in regulatory work. Now I deal with House and Senate staffers. One of the things I learned is that the people writing legislation simply do not have a lot of practical experience. You'd think that people writing environmental legislation, for example, would be environmental engineers or biologists, but in fact many are English majors.

"That's where my background in engineering helps. I understand the engineering behind the laws and, because of my project experience, I know how to get my point across. I can talk to these people and explain what I think they really need to know." Trask plans to specialize in international law, while at the same time staying current on environmental issues because "that's where the future is."

Virginia Giordano Fitzpatrick '75 was a member of an IQP team that analyzed the effects of new manufacturing technologies on industry. The project was completed in Washington for the U.S. Department of Commerce.

"The project did a lot to position me for

"Bootstrapping" a Project Center in Venice

FABIO CARRERA '84

Bootstrappers, from left: Richard J. Granfield '89, David George '89, Michael J. Kroese '90, Fabio Carrera '84, Michael R. Cote '90, John P. Lankhof '90 and Anthony S. Cucci '89.

For Fabio Carrera '84, it was an opportunity to do something for his hometown.

A native of Venice, Italy, and now a graduate student in electrical engineering at WPI, Carrera decided that Venice would be an ideal location for a WPI student project program. The city, he believed, would present a challenging environment where students could sharpen their technical and decision-making skills while immersing themselves in a rich, ancient culture. His dream was realized in October 1988 when the Venice Project Program was officially launched.

"There are nine other U.S. universities that run programs in Venice," Carrera says, "but we are the only one doing projects for the city."

Fittingly, the first Venice Interactive Qualifying Project (IQP) tested the feasibility of the project program itself. Sponsored by the Italian National Research Council and nicknamed "Bootstrap IQP," its objective was to establish the project program and identify the necessary logistics. The six students involved delved into the history of Venice, looked at its government (from the national level down to the local) and studied its educational systems. The students also identified companies and agencies with an interest in sponsoring future WPI projects.

"We wanted projects that would be useful to the sponsoring agency and beneficial for the city of Venice," Carrera says. "The 15 projects initially identified fulfill that criteria. They should make for outstanding IQPs, Humanities Sufficiencies and, potentially, Major Qualifying Projects (MQPs).

"Venice needs the involvement of WPI students and the dedication and professional skills they can bring to bear," Carrera adds. "This is a unique opportunity for WPI undergraduates to see their projects put to immediate use for the benefit of an entire city."

As a result of "Bootstrap IQP," two new student teams went to Venice to complete follow-up IQPs: "The Future of Science and Technology in Venice" and "The Revitalization of the Island of the Lazzaretto Nuovo." The objective of both projects was identifying additional IQP topics.

Among the more urgent topics uncovered by the early IQP teams are algae growth in the lagoon, the hydrodynamic equilibrium in the Venice canals, and the creation of a lagoon natural park. Other topics include a feasibility study of the use of solar electrification to power the boats used by Venice's public transportation system, a look at the reutilization of abandoned lagoon islands, and studies of lagoon pollution and archaeology, and the impact of acid fog on attempts to restore the city's ancient monuments.

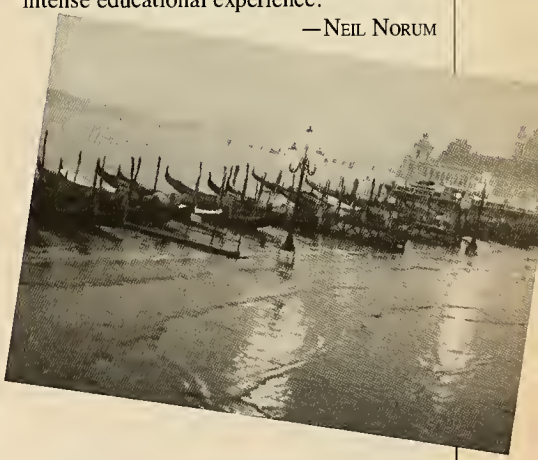
Carrera obviously is enjoying his part in the Venice Project Program. He teaches computer science at the University of Venice, which has recently agreed to a cooperative exchange agreement with WPI. This exchange will benefit both institutions, enabling Italian students to participate in WPI's educational programs and giving WPI students a chance to contribute to Venice and study at the same time, Carrera says.

The exchange program is expected to begin in winter 1990, according to Lance Schachterle, chairman of WPI's Interdisciplinary Studies Division and advisor for the "Bootstrap IQP."

With the Venice Project Program a success, WPI is "ready to continue working there on urban, environmental and scientific/industrial projects as part of WPI's expanding project efforts around the world," Schachterle says.

As the students who completed the "Bootstrap IQP" state in their report, "Europe in the 1990s is going to be vastly different than in preceding decades....Venice would be a unique educational experience and WPI could be a leader in monitoring the changes which Europe is going through and at the same time offer its students an intense educational experience."

—Neil Norum



JANET WOODCOCK

Work at remote project centers makes students "catch fire," says Susan Vernon-Gerstenfeld.

all the career moves I have made," she says. "It made me understand how to justify something—in business, that's an important skill. Having a great idea is not enough. You have to be able to prove to the decision-maker why your idea should be acted on. The project activity at WPI gave me a head start in the business world because I was taught how to present an idea in a clear, organized fashion."

Fitzpatrick worked full time until she had her first child, then worked part time, primarily for Control Data Corporation (CDC). "Project work was perfect preparation," she says. "I would go to companies and say, 'I have a baby and I have a skill. I can solve your problem.' I used this line for almost nine years.

"During this period of part-time work my husband was transferred to London and then to Barranquillia, Colombia. In both locations I was able to continue my project-type positions with CDC." While living in Colombia, Fitzpatrick severed her ties with CDC and began working as an independent consultant to local business people, doing inventory analysis and cash flow planning on personal computers and providing training on the systems she designed.

Two years ago she went to work full time for Computer Applications Learning Center in Morristown, N.J., where she is director of training. She says she spends much of her time training her own staff in presentation and project management skills. "I don't think I would have pursued any of the things I've done without the experience and confidence I gained at WPI."

Students who elect to do their IQPs at project centers outside the United States frequently have to cope with issues that are different from those experienced by the Washington Center students. The pressures of completing a project within seven weeks—while at the same time living up to professional-level expectations—are compounded by the challenges of adapting to a new culture.

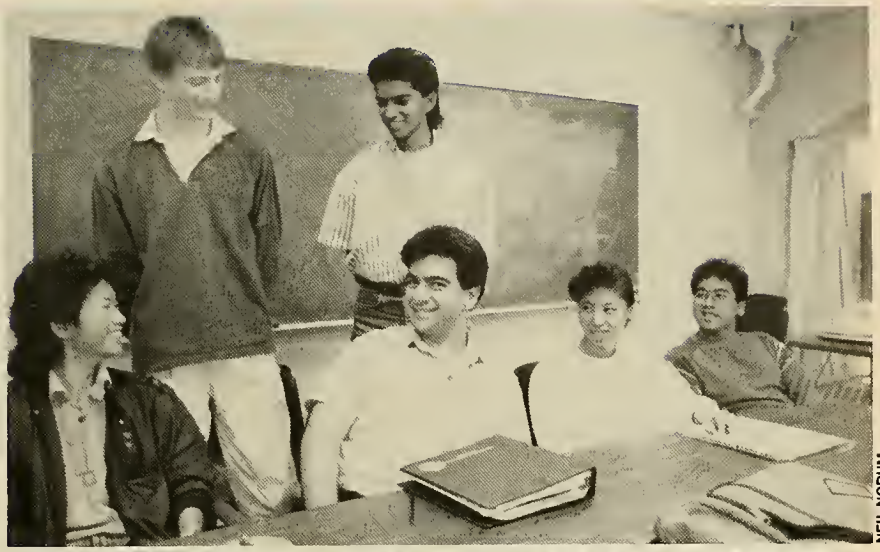
"I think our students are surprised by just how different things are in the United Kingdom," says John F. Zeugner, professor of history in the Humanities Department. Zeugner, who earlier served as an advisor at the Washington Project Center, was the first faculty advisor at the London Project Center when it opened its doors in the spring of 1987. He returned this past summer to advise additional projects in England.

It's the little things that make the biggest impressions on students, says Zeugner. For example, Britain's computing facilities tend to be less sophisticated than those in the United States (students now bring their own laptops). Also, American students must adapt to differences in the phone and mail systems, in technical terminology and in working hours.

"In London," he notes, "because you use words differently, you need to pay attention to conversation—it takes time to get the language sorted out. In addition, the values aren't the same. The British lack our frenetic work energy."

James S. Demetry, professor and associ-

Helping Students Cope Halfway Around the World



NEIL NORUM

From left (standing): Jacques and Titivanich; (seated) Taikitsadaporn, Eubbani, Huang and Ansvananda.

There are plenty of hamburgers in the heart of Bangkok, but no laundromats; the climate is too hot for jeans, but appropriate clothing is plentiful, cheap and stylish; and, because the head is considered the most noble part of the body and the foot the most abhorrent, it is considered a grievous insult to point one's foot at another's head.

Those are just a few of the things students who travel to WPI's new Bangkok Project Center should know. Thanks to the work of a team of WPI student pioneers, understanding the ins and outs of this Asian city will be almost as easy as ordering at any of the numerous McDonald's they'll find there.

Phakdiphibul (Prune) Ansvananda '92, Eddy Eubbani '91, Mei-Lun Huang '91, Lisa Taikitsadaporn '92 and David Titivanich '91, all natives or longtime residents of Bangkok, and Michael Jacques '92, who lives in Warren, Mass., spent the past summer recording their thoughts and observations for a handbook they wrote to familiarize future project teams (the first teams will arrive in January 1990) with Thailand's bustling capital city. The guide provides tourist information; looks at Thai history, culture, religion, politics and economics; and lists possible IQP topics.

Among the topics are an analysis of traffic congestion for the Rapid Transit Authority of Thailand (ETA) and studies of ways to improve living conditions for residents of the country's rural areas. The latter project would be completed in cooperation with the King Mongkut Institute of Technology, which has expressed interest in pairing WPI students with native students who would also act as translators.

Thailand, formerly known as Siam, is a monarchy. The majority of the country's 50 million people are Buddhists, and 85 percent speak Thai. The economy, once based largely on agriculture, has expanded to include manufacturing and high technology. WPI chose Thailand as the location for its first Asian project center because it is known as a stable, open nation, says Lance Schachterle, chairman of the Interdisciplinary Studies Division.

"Another consideration was the large number of WPI graduates and parents of current students who live there," Schachterle says. For example, Ruth Gerson, a Worcester native who lives in Bangkok with her husband, Michael Gerson '63, has agreed to serve as project coordinator for the new center.

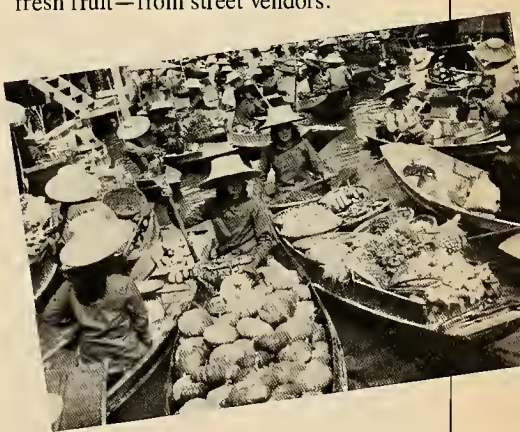
"Family, education, age and experience are very important to the Thais," Michael Jacques notes. "If you are young, without a college degree, as the project students will be, you have to prove yourself."

In their guide, the students advise WPI project teams to learn some Thai, because although many high-ranking officials speak English, most of the people they will encounter in their day-to-day lives do not. While WPI students should familiarize themselves with the currency, they will also need to learn the art of haggling, an integral part of Thai life.

Because of the taboos regarding the foot, students should not sit cross-legged or put their feet on furniture, lest they inadvertently point at someone. And, they will want to smile—a lot. In Thailand, smiles are used to express happiness, say "thank you," excuse inconveniences, or return a "wai" (the traditional Thai greeting that is given by raising one's hands, palms together, to the chin) to someone younger.

As an American from a small town, Jacques experienced firsthand what others will face when they travel to the Bangkok Center. The airplane trip—his first—lasted 46 hours, and he had to haggle to get his laptop computer through Thai customs.

Tall and lean, Jacques quickly learned to lower his body in the presence of elders and important people, and to get around the city on buses and tuk-tuks (three-wheeled vehicles used as taxis). He expanded his gustatory horizons by buying native cuisine—mostly rice, noodles, seafood and fresh fruit—from street vendors.



"The Thai students learned about their own country, with some help from an American peer," says Schachterle. "And they helped make it possible for future American students to do the same. So everyone gains by seeing technology and culture interact, literally across the globe."

—Bonnie Gelbwasser

JANET WOODCOCK

Completing a project overseas can bring about a "permanent blossoming" in a student, notes James Demetry.

ate head of the Electrical Engineering Department, concurs. "In London, our students expect to find people working nights like they do here, and they learn instead that, by and large, companies close at 5 p.m. and they have to make arrangements to use company libraries after hours."

In addition to getting down to work on their projects, newly arrived students must adapt to living in an enormous and complicated city, says Demetry. "They have to get used to the fact that there's no cafe or supermarket on the corner. Everything, from the fruit store to the bakery, is a mom-and-pop operation. Shopping can be time-consuming, especially if you don't have a car."

"There's a dizzying array of outside stimuli," adds Zeugner. "We encourage students to take advantage of the time they spend in London. There's a full panoply of whatever interests you in the human experience."

Demetry and Zeugner agree that electing to complete a project at a remote center offers a tremendous opportunity for growth. "Students have to overcome this alien experience and meet the high expectations of the sponsoring agencies. The work is highly focused and nothing gets in the way of that effort," says Zeugner. All told, it creates not only a challenging working environment for students, but imposes on them the need to demonstrate, often for the first time, a sense of collegiate and even national ambassadorship.

There's often "a permanent blossoming in a person's development," adds Demetry. Each student is taking a risk when he or she goes to London to do a project, but the projects are carefully prepared and supervised by competent advisors, so students are likely to succeed. "The very act of taking that chance and then succeeding helps build self-confidence and supports one's growth and maturation process."

The experience students have in remote project centers can prepare them well for their careers, no matter where they may choose to pursue them, Demetry says. "They understand that things are different in different parts of the world."

Sometimes, the benefits are even more tangible. Prof. T.E. Allibone, a member of Britain's prestigious Royal Society, has served as advisor to two WPI project teams. One group studied the patent literature of Dennis Gabor, a philosopher and Nobel Prize winner, and the inventor of holography. The second project was a study of the life and times of another Nobel laureate, Ernest Walton, one of two scientists who first split the atom.

"The first group began by studying Gabor's biography, so they knew a lot about the lifestyle of a very great scientist," Allibone says. "In that way they would know far more about one scientist than most students who know about the science a master has done, but little about the man himself." The students also completed a patent search to learn more about Gabor. "A patent search is very exacting. One learns to be precise in language as well as in thought. We are, in general, far too sloppy in speech, and Gabor wrote with very great precision. The scope of his patents was extremely wide so the students met many facets of applied physics and engineering of a very advanced character."

The group that investigated the life of Walton faced different challenges. "First I gave them the task of reading all the relevant papers of Rutherford [the British physicist] from 1908 up to the year 1932," Allibone explains, "so that they were probably better informed than 98 percent of all American students of physics on this one matter, a matter probably as important as any other this century."

"They discussed atomic bombs and nuclear power stations with specialists. Walton is alive, so they went to see the great man and his family and saw where he had done the great experiments. They also saw all his notebooks of those momentous days. I hope they got a sense of history from their work."

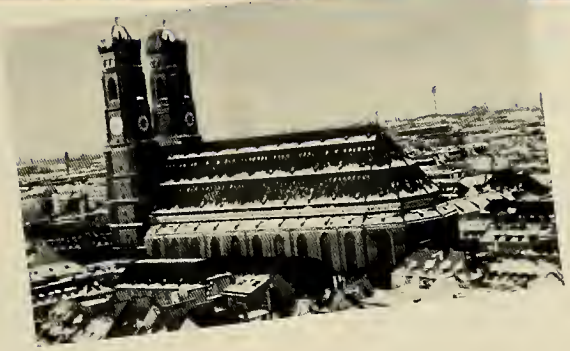
Graham Lindsay, superintending examiner in the Classification and Documentation Section of the U.K. Patent Office in London, says WPI students bring a lot to the agencies they work with in his country. "They're more extroverted, more outgoing than English students, who tend to be a little more on the reserved side. I think the biggest impact they've had in our organization has come from the conclusions they draw in their reports. We find these useful because the students look at the problems we present from a completely outside point of view and often come up with suggestions or solutions that set us off in new directions or cause us to look at things afresh. We've always valued the reports and taken very seriously the students' recommendations."

Paul R. Mancini '88 was in the first group of 12 undergraduates to complete projects at the London Project Center. He and teammates Jodi-Ann Medeiros '89 and William F. Noel '88 worked at the Worshipful Company of Scientific Instrument Makers. The company, which gives an annual award for the best commercially innovative technological instrument, asked the students to design a more formal way of selecting nominees and winners.

"At home, we go to class, crank out homework, go to project meetings, take exams and start again," Mancini noted in an article in the Summer 1987 *WPI Journal*. "Here, we have a problem to solve in a limited time within set parameters. We've got to develop resource networks quickly, building something from nothing in a strange place."

At an informal brunch for past and prospective London Project Center students, held during WPI's 1989 Homecoming, Mancini, who has remained at WPI to pursue a master's degree in mechanical engineering, added, "I chose to do my IQP in London because I wanted to study in Europe to experience something different. Our group was very motivated to enjoy ourselves in London, so we made a pact that we'd work our tails off from 9 to 5 to get the project done and spend the rest of the time enjoying ourselves. We were able to accomplish our goals because we worked very well together. After-hours we'd hit the pubs—it's part of getting acclimated to the

A Year of Pain and Personal Growth in Germany



SUSANNE MARIER

I remember fondly my first two months in Germany. I spent them taking an intensive language course at the Goethe Institut in Staufen, a small wine-making town at the edge of the Black Forest. Instead of taking a room in the student dormitory, I chose to live with a local family and I learned much about the wine-making process.

It was an incredible experience, perhaps the best time of my life. There were people of all nationalities at the institute, including college students and professionals from Japan, Costa Rica, Switzerland, France, Italy, Poland, Czechoslovakia and the United States. The only way we could all communicate was by speaking German, which was exciting.

Although I had taken the six courses in German that WPI offers, I needed additional instruction to prepare myself to study at a German college. There is a myth associated with junior-year abroad exchanges that says it takes just four to six weeks to achieve fluency in a foreign language. I learned instead that becoming fluent is a never ending process. I was not completely comfortable speaking German until my sixth month in the country.

My stay in Staufen taught me many things. I loved the fact that there was a village baker from whom you bought your bread. Next door was the butcher and across the street the gardener who sold vegetables and fruit. Small businesses like that are hard to find in America nowadays.

Sadly, those two months in Staufen did end and I packed my bags and headed to Munich where I would complete two semesters at the Fachhochschule München. Little did I know that the months ahead would be the most difficult of my life.

Munich was a far cry from Staufen. It was huge. It had a subway system that I could not figure out. On the streets, everything was moving—cars, buses and people.

My courses at the Fachhochschule were overwhelming. "What is wrong with me," I thought. "Why am I only understanding half of what is being said in class?" Fluid mechanics, Pascal, heat transfer—it seemed to me that these subjects just couldn't be understood very easily in German. On top of everything else, it was tough to make friends. My attempts to meet other students at the Fachhochschule just didn't seem to be working.

It was a time of great pain and personal growth. At some point I came to a powerful realization, one that continues to help me today: you can only do your best, and you can be proud of that. I was so concerned about doing things perfectly, learning all of the material, placing unfair and unrealistic expectations on myself all the while, that I forgot to enjoy life. With this new realization I began measuring my self-worth by how hard I worked, not by grades.

My story does have a happy ending. In January I passed my first tests, which told me it could be done—I could succeed at a German college. I made great leaps in fluency. I began thinking in German—one could almost say I became German. And, I made dear friends whom I now miss terribly. All in all it was a year that changed me in ways I find difficult to explain. I wouldn't trade the experience for the world.

—Erik B. Ellis '90

Editor's Note: Ellis, an Arizona native, spent his junior year studying in Germany, where he also completed an IQP.

Making a Difference on the Home Front

While it is modeled after the college's first remote project operation in Washington, D.C., the Center for Municipal Studies (CMS) is firmly rooted in WPI's backyard. Working through the CMS, students complete IQPs at city and town halls in central or eastern Massachusetts. The topics for these projects come from the cities and towns themselves, or from the Massachusetts Municipal Association.

CMS projects have elements of "realness," and they generate interest that motivates students, notes center director James S. Demetry, professor and associate head of the Electrical Engineering Department.

"Our students bring their skills to bear on problems at the first and most basic level of government, the level at which taxpayers have the best opportunity to influence how their tax dollars are spent," Demetry says. "While small towns may lack the luster and excitement of Washington or London, their problems are much more immediate."

The projects students complete through the CMS represent a broad spectrum of interests, including municipal finance and management, water and environmental resource concerns, public safety, education, land-use planning and control, transportation, and communication and data management.

In a recent project three students looked at the development of athletic fields in Holden, Mass. Their recommendations to the town covered financing methods, land acquisition, maintenance and rehabilitation, and possible locations for future fields.

Another group completed an analysis of the complaint handling procedures used by Worcester's Department of Public Works. The group advised the department to adopt a computerized complaint management system.

"In the CMS, all the ingredients are at hand for a superior educational experience," says Demetry.

—Bonnie Gelbwasser

culture. We went to the theater, to concerts, and we saw all of the sights."

Completing a project in London, says Mancini, "opened my eyes to the rest of the world. The most interesting thing to me was seeing the United States from the outside looking in. In the news you read about what happened from the English point of view, and then they write, 'Washington says....' You really come to appreciate the impact the U.S. has on the world. I know now that I want to travel more and do new things."

Aldo D'Amico '85 traveled to London in the fall of 1983 as an exchange student in a program with the City University of London, the predecessor program to the London Project Center. D'Amico says he made a lot of friends with whom he remains in touch. "They've come over here and two years ago I went back to London," he says.

D'Amico found the experience valuable when he began looking for a job. "I put it on my resume and it got a lot of attention at my interviews. I think it says to people that you are a person who is willing to try new things."

Six months ago, when he switched jobs and accepted a post as an electronic design engineer at Codex Corp. in Canton, Mass., his London project experience helped again. "There are a lot of European and Asian people working at Codex and I think the time I spent in England has helped to make me feel at ease with a wide variety of people and situations."

Paul Williams '84 spent six months in London as an exchange student before the establishment of the London Project Center, living with British students at Trent Polytechnic Institute. He later earned a master's degree at Rensselaer Polytechnic Institute and currently works at MIT's Lincoln Labs. "I did my IQP on the economics of Britain's secondary railways," he says. "I learned how to organize a report and dive into research, but what gives me the best feeling now is the realization that I've been over there—that I took advantage of an opportunity when it came about."

William Delphos '74 spent five months as an exchange student in London. A member of WPI's Board of Trustees since 1984, Delphos is president of Venture Marketing Corp. in Washington, D.C., and has written three books designed to help small and large U.S. companies obtain public-sector money and support for international business.

In London, Delphos' project focused on an accounting system that established a value for the "people side" of a business, which could be included on a company's balance sheet, something Delphos calls human asset accounting.

"The experience had a tremendous impact on me," he remembers. "All of a sudden I was interacting with people from around the world. The time I spent there changed my life. It gave me a tremendous edge when I came back and entered the M.B.A. program at Northwestern University. It gave me a global perspective.

"As I completed my project in London, it became quite apparent to me that the world was becoming smaller, and that people who understood how business is done, and done differently, in different parts of the world would have a tremendous advantage," he adds.

What he learned in London gave him an edge in business school and, later, when he went to work for an electronics manufacturer in Illinois. "I was fortunate to take over the operations of a division that had tremendous international opportunity," he says. "I was very comfortable with that. I was able to double the size of the division on the strength of international markets."

His work at that company led to a White House appointment as senior vice president of the Overseas Private Investment Corp., where he helped U.S. companies compete in international markets. He later left government to start his own company.

"I am one of the biggest fans of the Plan," Delphos says. "It's time has come again with the concept of global engineering. I think it's a remarkable time in WPI's history. As the world becomes a smaller place, WPI can provide a training ground where students can work, not only on projects, but with people from different cultures who may look at doing things from a different perspective."

Gelbwasser is assistant director of the WPI News Service.

DNA fingerprints are a big breakthrough in law enforcement. But genetic detective work can also unravel paternity and other puzzling cases.

INVISIBLE EVIDENCE

BY SUE DE PASQUALE

When Vilma Ponce and her two-year-old daughter were stabbed to death in their Bronx apartment two years ago, police were in a quandary. Though the pregnant woman's common law husband fingered 38-year-old Jose Castro as the murderer, police had no evidence placing the handyman at the scene of the crime. Then, during questioning, detectives noticed a tiny bloodstain on Castro's watchband.

They sent the stain to Lifecodes Corporation in New York, where analysts examined its genetic makeup and came up with a "DNA fingerprint"—a means of identification that relies on the genetic blueprint unique to each individual. Lifecodes reported that the DNA fingerprint found on the watchband directly matched that of Vilma Ponce's blood. The odds that the match could have happened by chance? A staggering one in 189,200,000, according to Lifecodes' analysts.

Not since Sir Edward Richard Henry at the turn of the century developed a system of identification using the human fingerprint have police and forensic scientists been so excited about a breakthrough in the field of law enforcement. Developed by English geneticist Alec Jeffreys and first used in the United States to score a courtroom conviction in 1987, DNA fingerprinting has figured in at least 200 court cases across the United States, some of them involving capital crimes. The technique is being used to prove everything from murder and rape to paternity and citizenship.

"It's incredibly effective," says Joan Bailey-Wilson, a 1975 graduate of Western Maryland College who is now associate professor of biometry and genetics at Louisiana State University. "The truth is that nobody's DNA is exactly the same unless you're an identical twin. And it's not just a tool for the prosecution. It can also keep people who are unjustly accused from being convicted."

Consider the first murder suspect ever to be identified and charged on the basis of his genes, in a case that became the basis of Joseph Wambaugh's recent novel, *The Blooding*. Three years after a teenage girl was raped and murdered near the English town of Enderby in 1983, 15-year-old Dawn Ashworth was also raped and strangled as she walked home from a friend's house. Police arrested a suspect in the cases, but found that his DNA fingerprint did not match the print found in semen samples taken from both murder-rapes. They freed the wrongly accused teenager, then asked 4,000 local men to submit blood samples.

When 27-year-old Colin Pitchfork tried to send his friend to take the blood test for him, police arrested him and found that his DNA made the crucial match. Pitchfork was convicted and sentenced to life in prison.

Traditional fingerprints are considered very reliable; every individual has a one-of-a-kind pattern of rounded whirls. But even when a forensic scientist declares a match, there can be points of dissimilarity between the two prints, Jeffreys contends. The analyst must then make a subjective judgment as to whether a dissimilarity can be sufficiently explained.

Moreover, "you don't always have a full fingerprint or a surface that will take a print," says Janice Knepper, assistant professor of biology at Villanova University. Investigators are much more apt to recover blood and semen stains, bone fragments, or hair roots on the victim or at the scene of the crime. No matter what type of tissue sample an individual's cells are taken from, the DNA will be the same.

Conventional forensic tests—such as blood-group analysis and protein analysis—must usually be performed on samples less than a month old. Even then, these tests can only *exclude* a particular suspect, or conclude that the suspect belongs to a group of individuals who have certain traits in common. They can't target an individual as the sole source of a biological sample. By contrast, DNA fingerprints can be gleaned from tissue samples that are many years old, provided they've been kept cool and dry. (One researcher was even able to examine the genetic sequence of DNA preserved in the frozen muscle of a 40,000-year-old mammoth.) And a DNA match can mean almost 100 percent certainty.

Unlike the series of swirls that comprise a thumbprint, the DNA fingerprint is made up of stripes—similar to the UPC bar code you find on cartons of milk and boxes of frozen food. These stripes derive from the fact that there are repetitive sequences or "stutters" that appear in each individual's chain of DNA. In the early 1980s, Jeffreys discovered that he could isolate the portions of the DNA molecule, known as RFLPs (Restriction Fragment Length Polymorphisms) that contain these stutters. He used a restriction enzyme (which acts as a molecular scissors) to chop up the double strands of the DNA at these specific sequences, and then added radioactive probes, which attach themselves to fragments of DNA that they "fit"—much like the teeth of a zipper.

Once that's done, forensic scientists can expose the fragments on an X-ray film and produce a pattern of charcoal-colored bands. Each band represents the spot where the radioactive probe has "zipped up" with its correct partner strand. If the band lengths on DNA samples taken from both the crime scene and the suspect line up perfectly, the analyst relies on population genetics to determine the statistical odds that the match could have occurred by chance.

"The really nice part is that when you're all done, you can take that picture into court," says James Werner, vice president for administration at Cellmark Diagnostics Laboratory in Germantown, Maryland, one of the nation's three commercial DNA typing labs. "The jury can visualize it. You can say, 'Here are the four (bands) from the semen found on the victim. Here are the four (bands) from the suspect's sample. As you can see, they match.' "

RFLPs are chromosomal regions of high variability—so variable, in fact, that the odds nearly preclude two individuals sharing identical molecular sequences. By examining several different RFLPs, forensic scientists say they can reduce to one in several billion the chances of a coincidental match. Considering that the chance for an error in matching with more traditional biochemical tests is about one in 1,000, it's easy to understand why the law enforcement field is so enthused about the DNA technique.

The DNA fingerprint resembles the UPC bar code found on cartons of milk.

"The best (DNA typing) companies today are using as many RFLP probes as they can get their hands on," explains David Adams, assistant professor of biology at Worcester Polytechnic Institute. "The goal is to come up with a set of five or 10 RFLP probes that look for grossly different sites on the chromosomes and that, when used in certain combinations, are irrefutable. That's what the public is looking for."

While molecular biologists like Adams assert the incontrovertibility of DNA typing, they worry that the technique has arrived in the courtroom too soon, before laboratory standards could be put into place. The Castro case indicates that their worries are not unfounded. In the first serious legal challenge to DNA fingerprinting, Justice Gerald Sheindlin ruled in August that the evidence submitted by Lifecodes in the Bronx case was scientifically unreliable.

Sheindlin's decision concluded an uncommonly long 12-week pre-trial hearing on the admissibility of evidence—a hearing that was itself highly unusual. In May, expert witnesses from both the defense *and* the prosecution joined together to declare that the DNA typing done by Lifecodes was so flawed as to be inadmissible. The scientists said that the analysis lacked proper controls, did not objectively evaluate the DNA band lengths, and made unreliable use of population genetics.

According to laboratory standards established by Lifecodes, two bands are accepted as a match if their positions differ by less than three standard deviations (in this instance, one s.d. equals 0.6 percent of molecular weight), noted Eric Lander, a defense witness in the case and an internationally known geneticist at the Whitehead Institute for Biomedical Research in Cambridge, Massachusetts. When scientists for the defense examined the analysis done in the Castro case, they found that two bands declared a match actually differed by more than three standard deviations.

In their consensus statement, the four expert witnesses stressed the need for the scientific community to establish laboratory standards for this fledgling field. "At present, forensic science is virtually unregulated—with the paradoxical result that clinical laboratories must meet higher standards to be allowed to diagnose strep throat than forensic labs must meet to put a defendant on death row," Lander noted.

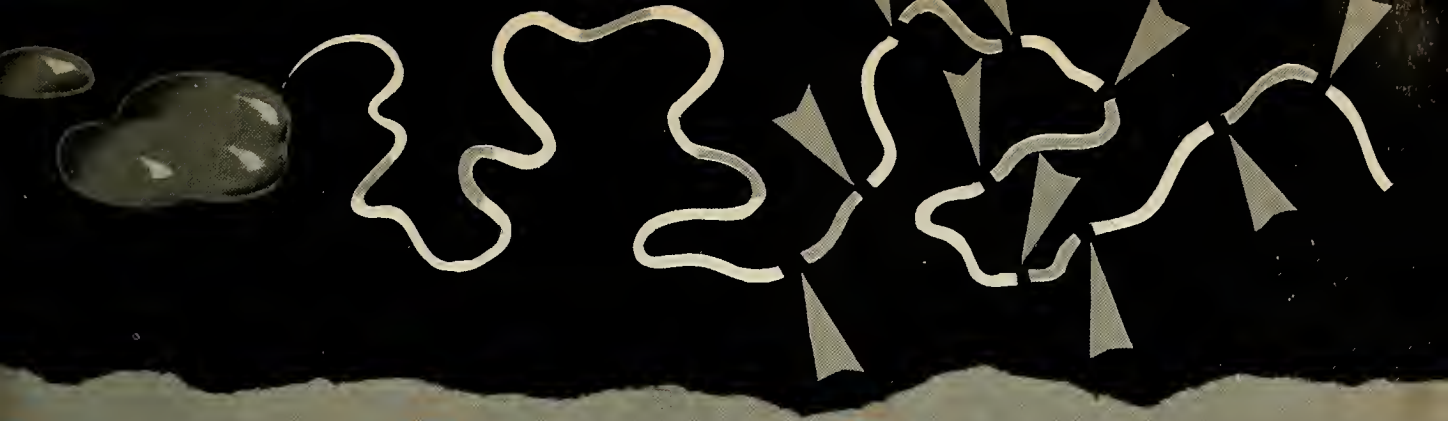
Charles Rozek, associate professor of biology at Case Western Reserve University, agrees. "There has to be some criteria established in terms of evaluating the results of DNA typing. It's a very sophisticated type of testing . . . and inconsistencies can arise."

"In particular," explains Villanova's Knepper, "the quality of the DNA you start with can influence the results. And, if samples have not been processed in an ideal manner, the bands that you look for may be artificially altered." There's also room for error in interpretation. "Raw data is raw data," she says. "Although the technique itself is very objective, there's an individual who looks at and interprets the data. That's where it helps to have a standardized approach."

Justice Sheindlin instructed lawyers in previous DNA cases—some 200 in all—to re-examine their trial records to see whether appeals would be warranted. Meanwhile, the way is clear for the Castro trial to begin, without the DNA evidence, of course.

What does Sheindlin's ruling mean for future court cases involving forensic DNA

Sue De Pasquale is assistant editor of the Alumni Magazine Consortium.

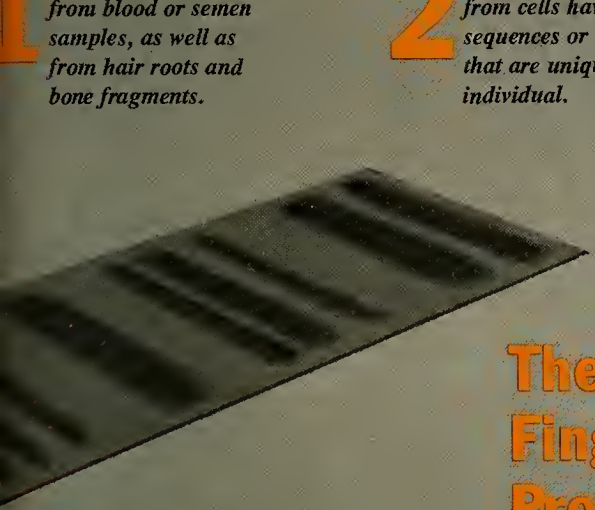


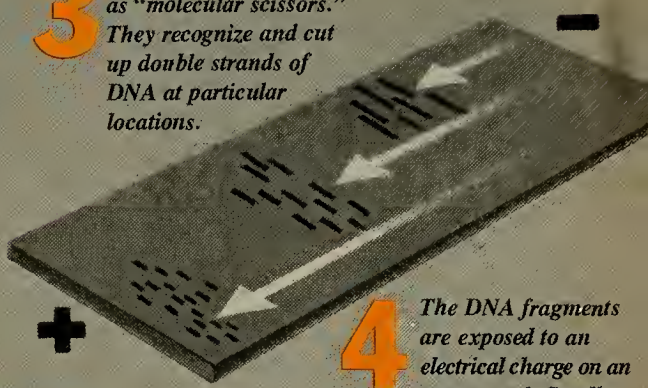
The DNA Fingerprinting Process

1 *DNA can be gleaned from blood or semen samples, as well as from hair roots and bone fragments.*

2 *The chains of DNA extracted from cells have repetitive sequences or "stutters" that are unique to each individual.*

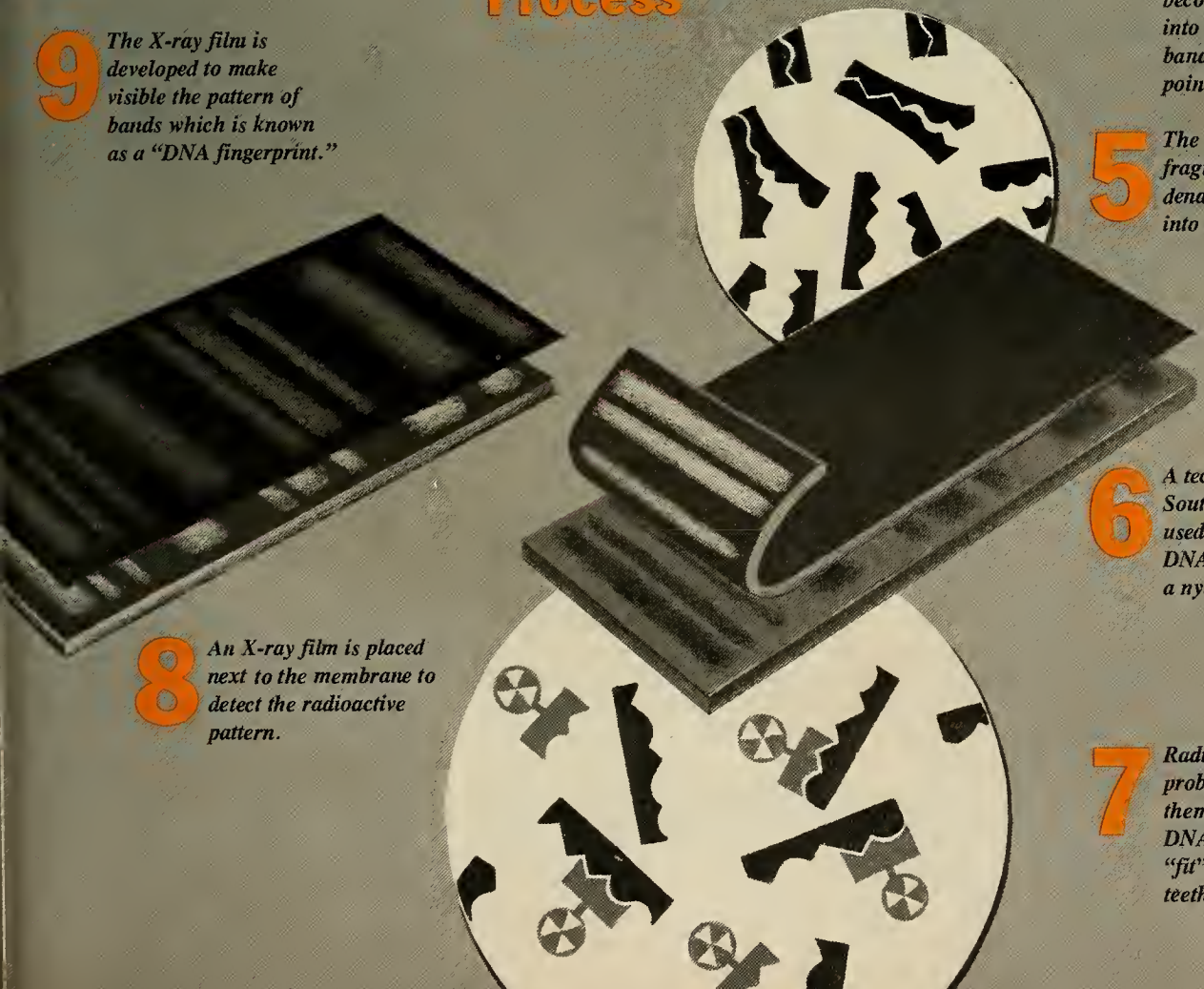
3 *Restriction enzymes act as "molecular scissors." They recognize and cut up double strands of DNA at particular locations.*





4 *The DNA fragments are exposed to an electrical charge on an agarose gel. Smaller particles move more rapidly than larger ones, so the DNA becomes separated into bands by size—bands that are at this point invisible.*

5 *The double-stranded fragments are denatured (separated into single strands.)*



6 *A technique called Southern Blotting is used to transfer the DNA band pattern to a nylon membrane.*

7 *Radioactive DNA probes attach themselves to specific DNA sequences they "fit"—much like the teeth of a zipper.*

8 *An X-ray film is placed next to the membrane to detect the radioactive pattern.*

9 *The X-ray film is developed to make visible the pattern of bands which is known as a "DNA fingerprint."*

AP WIDE WORLD

Gary Dotson was jailed in 1979 for a rape he didn't commit. His alleged victim recanted her story in 1985. Charges were officially dropped last year, when DNA testing proved his innocence.

typing? Most lawyers and scientists believe that his decision actually upholds the validity and admissibility of DNA testing when it is properly conducted.

"The procedure itself is scientifically sound. It has general scientific acceptance—period," says Oliver Schroeder, Jr., director-emeritus of Case Western Reserve University's Law-Medicine Center. "The question will be, as in a number of scientific situations, whether the test was done properly. We need to make sure that the crime labs have the necessary instruments and experience and education." In order to assure that laboratory results are indeed accurate, Sheindlin recommended that courts hold pretrial hearings on a case-by-case basis, whenever DNA evidence is going to be introduced.

"The typing that Lifecodes did in the Castro case was in the early days of DNA typing, two to three years ago," explains WPI's Adams. "Lifecodes has more reliable techniques today. My guess is that it's just a matter of time until the field becomes very standardized. I'm firmly convinced that once the correct assortment of probes is found, the technique will be widely accepted by the courts." Two national panels—one from the National Academy of Sciences, the other from the Office of Technology Assessment—are looking into creating standardized procedures.

Meanwhile, cases continue to pour into the four major labs in the nation equipped to do forensic DNA typing. The FBI's laboratory in Washington, D.C., gets 20 to 40 requests each week from all over the country. With a staff of just three scientists and seven technicians, the lab has a challenging workload, says the FBI's Catherine Theisen Comey, a research chemist. That's why the nation's premiere law enforcement agency has taken the lead in helping state and local crime labs set up their own DNA testing sites.

Comey and her colleagues have offered two courses in DNA typing, training 65 analysts in the technique so far. Their work is already paying off: two local crime labs—in Nassau County, New York, and Norfolk, Virginia,—have started accepting their own casework. And several other labs "are close to up and running," she says.

Crime lab technicians aren't the only ones who must be trained in this new field of forensics: Police officers and attorneys need to know how DNA evidence should be handled once it's found. At CWRU's Center for Criminal Justice, law enforcement officials learn that moisture and high temperatures are most damaging to DNA samples (wet blood stains degrade in two days, semen stains degrade in a week). Thus, if they're unable to send a sample to the crime lab within a week, investigators should put it in the freezer. Such information is presented at frequently held seminars, which bring together law enforcement officers and forensic experts from all over the country, explains CWRU's Oliver Schroeder.

Some argue that DNA typing arrived in the courtroom too soon, before lab standards could be established.

At the FBI, when Catherine Comey isn't instructing others, she's exploring a new method of DNA typing at the Bureau's Forensic Research and Training Laboratory in Quantico, Virginia. This technique, known as PCR (polymerase chain reaction) gene amplification, enables analysts to extract usable DNA "from blood stains the size of the head of a pin and from semen stains that are even smaller," she says.

PCR is like a molecular Xerox machine—it can make a million copies of specific DNA sequences. With these copies available, scientists can examine differences in the length and/or base sequence of the gene, and classify an individual into one of several different types.

RFLP probes, like those used by Lifecodes and Cellmark laboratories, require long, intact chains of DNA. That means, for example, that blood stains must either be relatively large (about the diame-

ter of a dime) or extremely well preserved. But the PCR method—pioneered by the Cetus Corp. in Emeryville, California and researchers at the University of California at Berkeley—allows forensic scientists to examine much older and tinier tissue samples that have been degraded by prolonged exposure to sunlight or enzymes. One scientist actually cloned small fragments of DNA from the tissue of a 2,400-year-old Egyptian mummy. Researchers say the PCR technique holds great promise for criminal cases involving evidence that is years old.

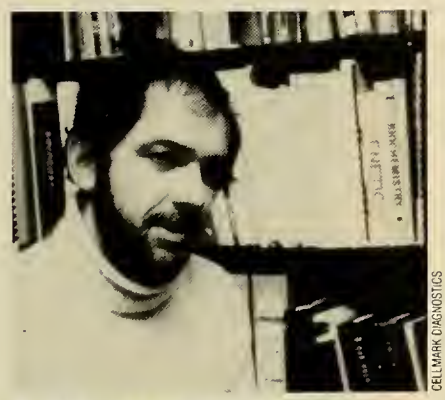
Take the case of Gary Dotson, the Illinois man who was convicted of rape and jailed in 1979 on the basis of testimony made by his alleged victim, who recanted her accusation in 1985. Illinois Governor James Thompson granted Dotson clemency that year, but refused to proffer a pardon, saying he wasn't convinced of the verity of the woman's reversal. In August 1988, California scientist Edward Blake used the PCR technique to examine a semen stain on the decade-old underwear saved as evidence in the case. Blake concluded that Dotson was not among the 5 percent of men who have a genetic print that would match the stain. The state of Illinois subsequently dropped its 12-year-old charges against Dotson.

While the PCR technique has distinct advantages over RFLP probes, there is a tradeoff. "It's just not as informative," Comey says. Though PCR can be used to exclude suspects with certainty, it can't pinpoint an individual as the sole source of a sample. The particular amplification method she's working on now, which examines the sequence of one gene, can pigeonhole an individual into one of several different types and subtypes. That may be a far cry from the one-in-a-billion odds offered by combinations of RFLP probes; but in instances like the Dotson case, it's all that's needed to exclude a particular suspect. And, as PCR researchers gain the ability to examine several different gene sequences, the gene amplification technique will become progressively more discriminating, Comey predicts.

Once analysts have determined that two different DNA fingerprints match up, they turn to population studies to figure out the statistical odds that the match occurred by chance. Scientists have found that certain genetic traits occur more frequently in particular ethnic, racial—even geographical—populations; thus, DNA labs must gather genetic statistics on these subgroups. One way to compile these databases is by using blood samples routinely taken by hospitals. The FBI is more enterprising. New agents are asked to submit to a voluntary blood test, and those who do so are rewarded with a T-shirt that reads, "You leave it/We cleave it."

Currently, each DNA lab relies on its own population databases. But, as more and more local and state crime labs start setting up their own testing sites, Comey believes that they'll come to rely on standard population statistics provided by a single source—quite possibly the FBI.

In the meantime, commercial firms like Cellmark and Lifecodes are finding that paternity suits mean big business. Traditional tests of parentage are based on the presence of key molecules in the blood. A combination of tests must be used to ensure a high degree of accuracy, which means



CELLMARK DIAGNOSTICS

British researcher Alec Jeffreys developed DNA fingerprinting.

an analysis can take many weeks to complete. With approximately 200,000 paternity suits filed each year in the U.S., the time delay can be costly. And, says Western Maryland's Bailey-Wilson, blood tests don't always turn out to be completely conclusive: In many cases they can only exclude a man from being the father.

DNA typing provides a "yes/no" answer, says Cellmark's Werner—and can be completed within two weeks, at a cost of about $350. Using two different probes, which together detect 40 to 60 different DNA segments, Cellmark analysts compare samples taken from the child with those taken from the mother and the putative father. The analyst identifies and marks all the bands that are in the same place in the mother's and child's band patterns. Every remaining bar in the child's DNA fingerprint should match up with the man's DNA fingerprint, if indeed he is the father. Cellmark has found that many men decide not to go to court once the DNA results conclude their paternity.

The same testing procedure can help solve immigration disputes. The first case of this kind arose when a Ghanaian boy, who was born in Great Britain and emigrated to live with his father in Africa, decided in 1983 that he wanted to return to England to be with his mother. British authorities believed he was in fact the woman's nephew, not her son, and would not grant him British residency. Standard blood tests were inconclusive. Then researcher Jeffreys stepped in, taking DNA fingerprints of the boy, as well as of his purported mother and siblings. The results clearly showed that the woman was the boy's mother, and the authorities allowed his immigration.

DNA typing for paternity isn't limited to the world of humans. Werner says Cellmark has processed several cases for zoologists working to preserve endangered species. "The intention is to breed the species to bring the population up, but not to inbreed," he explains. When species inbreed they become less resistant to disease, and they lose their ability to withstand changes in their environment. Cellmark tested DNA from animals at two different zoos to find out whether the two populations could be crossbred successfully. Breeders of dogs, fish, and birds also rely on DNA typing to determine pedigree.

Studying the evolution, behavioral ecology, and sociobiology of animal populations will be much easier, thanks to advances in DNA analysis. But what about forensics? What does the future of DNA typing hold in store for crime solvers?

In California, convicted sex offenders must now provide blood and saliva samples when they are released from prison. That state's "DNA fingerprint bank" complements the FBI's efforts to digitalize DNA analysis results—in much the same way traditional fingerprints are currently translated into computer codes and put into a national database.

Comey says the Bureau's goal is to establish a computerized system of DNA profiles. These could be used to identify missing persons or abandoned babies, and to track down serial killers and repeat sex offenders. With such a system in place, local police would ideally be able to take a DNA fingerprint found at a crime scene, plug it into the FBI's central computer—and come up with a match.

"DNA typing is the most powerful technique to come along in forensics in a very long time," concludes WPI's Adams. "Those of us who do it have a gut feeling for its accuracy and its power."

A cadence of crickets. Riffs of leaves. A slow hush as winter sets in. Autumn reminds us of childhood, of change, of memory itself.

Songs

One morning last summer I drank my coffee outside amid rasping incantations that pulsed from the shade trees above our porch. Though I am past 40, I was instantly a kid again, borne backward in time by vivid recollections of summers past, of whirring sprinklers and water balloons, Good Humors and baseball cards, Kool-Aid stands, squished tomatoes, fireflies in jars, sand in swimsuits, and playmates returned from their family vacations looking brown and smug and vaguely changed, as if the mystery of their adventure had endowed them with some subtle, transfiguring aura.

Then as now, however, the cicada's song and that of its quieter cousin the cricket, were for me not summer songs, but always the first songs of autumn. Impalpable at first, like a worry at the back of one's mind, they strengthened in August under Sirius, the Dog Star, reminding me more each day—with a twinge of both wonder and anxiety—of the swiftly approaching school year. Soon new textbooks were studied in September to the rhythm of these wan dream-tunes, as I sat at my desk by the window on some golden day near the equinox. The cricket cadence was lulling, and filled my ears so neatly that it was obvious only when it ceased. Then a cicada would start, burring hot and steady till some unknown force pulled its plug.

By October these songs were mournful. Frost threatened nightly. Some stubborn cicada in a sycamore, on the edge of a ballfield by the school, might ring out a few final phrases, while the once-incessant crickets writhed invisible in the weedy lots and prairies, their notes half-frantic and broken. It was not their dying that moved one, but a sense of something terribly old, a gut-centered grasp of how ancient were their sounds of persistence, the same sounds, altered less than stone and rock, that touched the ears of apes in trees before the time of man.

There is a second song of autumn, but it is not sung by animals. Leaves, pounded to gold and copper by the anvil of freezing nights and the hammer of biting winds, rustle and whisk to the stroke of daytime breezes. Dry and crisp, suspended in multihued millions or tossing and drifting along lawns and sidewalks, their music rises and falls, grand and symphonic in the dense treetops, sedate in the low boughs and bushes, or riffing madly along asphalt and cement like brittle bursts of jazz. So poignant are these melodies, so ripe with subtle leaf-song is the smoky air of autumn, that it broke my concentration as a child, made me near to a hopeless dreamer, got me lost on my way home from school. Then, whole streets seemed able to sing, the elms full of whispering music, twisting measures of rust and ochre, the maples rattling scarlet and spewing bright notes on the sidewalks. A boy could get lost in an alley, for hours it seemed, ostensibly sorting good junk from bad, but in fact drawn along by these sirens.

The third song of autumn is a song of quiet. It is not a deep quiet, like that which broods over winter, but rather a diminish-

ment, a slow hushing that heralds the approaching cold. Summertime's clamor subsides to a lullaby in a hundred gradual ways: Picnics and parties grow scarce, beaches and poolsides empty, backyards stand silent on school days. With the first frigid air, our interests shift indoors. The voice of the weather softens: Storms are less violent, less noisy. Even my cicadas and crickets are but filtered voices, back-alley minstrels on a street where the band has gone home. The great chorus of birds that held forth through the warmest seasons has grown silent by September. A blue jay may call, a crow croak briefly, a sparrow or goldfinch twitter, but it is mostly remnant chatter.

And what of the great flocks of geese? Unless you seek them on the marshes, they are mere sky-writers far overhead; their honking, if loud, is yet a passing thing that is hastily headed elsewhere. More often it is a bug in the ear, a toy horn heard while raking leaves, coming into tune like a short-wave channel, faint, then fixed and surprising. In that same childhood, walking that same junk-rich alley toward that same dream-drenched school, I would look up, right hand clasping books and lunch, left hand shielding the sun, to pick out the straggling skein being drawn across the sky. The honking was intermittent, wispy as cirrus and nearly as high, the notes squeaky, thin, sucking in and out like some toddler weakly humming to himself. Such are the quiet, hushed songs, the lullaby songs of autumn.

The final song of fall is one of remembrance, of memory itself. I once was told, and it may be true, that the word for autumn in certain Indian dialects translates as "reminder." Indeed, it is the season that reminds us: of seasons past, of our youth or childhood, of the hush that comes before night or death, or of simply the coming cold. It is a song partly tinged with sadness. For it reminds us not merely of change and decay, but of that which cannot be fathomed, that something we cannot know or find, something beyond attainment that we long to grasp, whose existence we sense but cannot make sense of, a broken rhythm in the thrashing leaves, a glimmer of color and light tossed before us like a visiting truth and then just as quickly blotted. If spring is the time of longing, fall is the time that reminds us that the longed-for is lost. That which is elusive and unnamed seems condensed in natural forms, stamped in proclamations of red and gold, decrees of mist and frost and smoky glow, which then, in a bright flicker of time, are burnt before our wondering eyes and reduced to winter's ash. Yet little of this beauty is lost. Memory, that final and fiercest song of autumn, has preserved the glory of existence of which these and all things are a part. Next year, when the insects drone, and the breezes strum the leaves, and the hush of autumn entwines us, memory will store the notes, then add them to its mellow chorus.

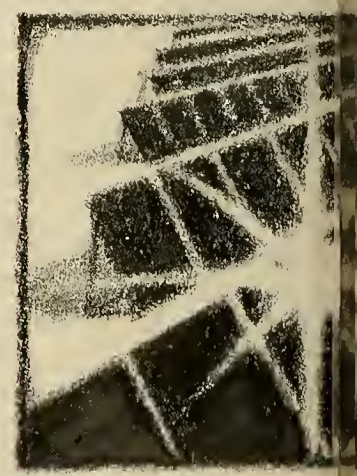
Jack Wennerstrom is a Baltimore area naturalist and writer.

# of Autumn

By Jack Wennerstrom

PETER HOWARD

GENERATING ENERGY OPTIONS



Demand has surged for electric power. Increasing efficiency may be the smartest way to buy time to develop alternative fuels.

By Leslie Brunetta

ILLUSTRATIONS BY ALLEN CARROLL

The hot, humid summer of 1988 was a hellish one both for electric utilities and for many of their customers. East Coast television and radio stations hammered out the message that blackouts threatened unless consumers switched off lights and appliances. Brownouts set some air conditioners stuttering and computer screens flickering. And, heeding utility cries for help, some big factories shut down machinery—and scrambled production schedules.

Like sparks flying off the over-burdened power grids, newspaper and magazine articles flared warnings that the end was near for our electrically pampered life. The summer of 1988, they said, was just the first of many that would punish us for our dependence on air conditioners, refrigerators, microwaves, computers, and copying machines. As recently as this past June, *U.S. News & World Report* predicted that it wouldn't be long before Americans were confronted with "dimmed lights, balky computers, stuffy office buildings and perhaps even total blackouts in some areas."

The good news is that the experts—those watching energy trends from within academia and the utilities, as well as environmental advocates—agree that many of these articles were alarmist. We aren't facing the electrical equivalent of the 1979 oil crisis, according to Alan F. Destribats. The vice president of demand and least cost planning for New England Electric System (NEES) earned his M.S. from Worcester Polytechnic Institute (WPI) in 1975. "If anything," says Destribats, "that summer showed that electricity supply and demand can be managed with relatively little disruption even in the most trying circumstances."

But the bad news is that the summer of 1988 can't be dismissed as a fluke. We may not be facing a crisis, but we are facing the jarring reality that our demand for electricity is increasing just when the options for generating new supply are shrinking. Both of our traditional sources of electricity—nuclear and fossil fuels—present an array of environmental, economic, and political problems that make the construction of new utility plants extremely difficult. Meanwhile, the alternative sources trumpeted during the '70s, such as solar and wind power, have provided virtually no electricity during the '80s.

"The message of summer 1988 wasn't that the sky is falling," says Robert Stein (WPI '71), vice president for engineering and energy planning at Central Vermont Public Service Corporation. "But it was a message that we need to do serious thinking about what direction we're heading."

From World War II until the '70s, U.S. demand for electricity climbed steadily, outpacing the growth of the gross national product (GNP). But the oil-supply shocks of the '70s seemed to prompt a relative cutback in electricity use. In 1974, for the first time since the Depression, national electricity sales fell behind the previous year's. Sales growth reappeared in 1975 and continued throughout the '70s, but lagged behind GNP growth. Although the utilities were disturbed by the prospect of sagging business, environmentalists and economists applauded Americans for insulating their homes and offices, adjusting thermostats, and otherwise cutting back on energy waste.

But by the mid-'80s, the effects of the oil crisis seemed to have worn off. As fuel prices dipped, electricity sales started to climb. Today, both our "baseload" or normal demand for electricity, as well as our "peak" demand—reached when everyone cranks up the heat or air conditioning—continues to escalate. During the summer of 1988, peak demand in the utility region formed by Pennsylvania, New Jersey, and Maryland jumped from 1987's mark by 2,500 megawatts (MW), the amount of electricity usually expected to meet the ordinary needs of some 3,375,000 people.

It's true that many industrial processes once fueled by oil or coal now use electricity. It's also true that the commercial sector increasingly relies on computers and other electrically powered tools. But most of the renewed demand is due to a near revolution in residential use. By one measure, we've done well. Smaller car engines, increased insulation, and other energy-saving measures taken since 1960 have slashed total energy consumption—oil, coal, gas, and electricity combined—in the average U.S. household by 25 percent. But meanwhile, our use of electricity has jolted upward by about 150 percent. Increased reliance on big appliances and electronic gadgetry has been partly responsible. But the real culprit is increased use of home air-conditioning and electric heating systems. Although less than one-fifth of America's total housing stock is heated by electricity, about half of all new single-family

homes and an even larger proportion of new multi-family dwellings are equipped with electric heat, according to Cambridge Energy Research Associates (CERA), an international research and consulting firm. And about two-thirds of new homes come equipped with central air conditioning.

Electric heating's unsurpassed reliability and convenience play a part in this switch from other heating fuels, but price is also a factor. The price of electricity has actually decreased in many parts of the country since the early '80s, due to cuts in corporate income tax rates and in the cost of fossil fuels.

At the same time that demand is surging ahead, utility plant construction has virtually stalled. The '80s saw a great expansion in supply capacity—an increase of about 25 percent, or 140,000 MW, according to CERA. (A MW equals one million watts, or the amount of power needed to illuminate 10,000 bulbs of 100 watts each.) But almost all of that new capacity resulted from the construction of coal and nuclear plants ordered before 1975. Every nuclear plant ordered since 1974 has been cancelled. Moreover, the U.S. Department of Energy estimates that a majority of coal-fired plants will be near retirement age by the mid-1990s. Clearly, we could be headed for a serious squeeze.

Meanwhile, Americans seem to be increasingly uncomfortable with the nuclear and coal plants we already have. Pennsylvania's Three Mile Island (TMI) accident and subsequent public resistance to the licensing of New Hampshire's Seabrook, Long Island's Shoreham, and other nuclear plants make it questionable how many existing plants will achieve their full "natural" life span. As a show of opposition to the very idea of nuclear plants, the citizens of Sacramento, California, recently voted to shut down the already licensed and operating Rancho Seco plant. And now coal plants, too, have become targets of public concern.

Leslie Brunetta's most recent article for the Alumni Magazine Consortium was on summer reading. The free-lance writer lives in Somerville, Massachusetts.

Simply shutting down existing plants isn't much of an answer to our fears about the environment and safety. Nationally, coal provided 57 percent of our electricity in 1987, while nuclear plants supplied another 18 percent. What's more, even if our demand for electricity grows by just 2 percent per year, says CERA, we'll need an additional dozen coal or nuclear plants, or their equivalent, every year.

So what's the answer? Every option currently used or on the drawing board has substantial costs and benefits that make arriving at a consensus extremely difficult. Here's a quick look at how those options compare.

COAL

Coal is a plentiful and cheap domestic fuel. At its current rate of use, the United States has about a 200-year supply, according to experts. At a time of record foreign trade deficits, such a huge domestic fuel reserve seems especially attractive.

Unfortunately, coal is also extraordinarily dirty. Burning it produces most of the atmospheric sulfur dioxide that causes acid rain, as well as massive quantities of carbon dioxide that contribute to the global warming trend, or greenhouse effect. Some help in cleaning up these emissions is on its way. In response to stricter EPA pollution standards, some plants have already installed "scrubbers" on smokestacks, significantly reducing both sulfur and nitrogen oxide emissions. And demonstration plants have proved that new techniques, such as turning coal into a fuel-gas before it's burned, can further reduce dangerous emissions. Except carbon dioxide. So the greenhouse problem remains.

And coal presents other problems. "For every acre of underground coal mining, five acres of land are liable to sinking," says Esther Iglich, associate professor of biology at Western Maryland College (WMC) and adviser to a student environmental activist group. "With strip mining, rain runs over exposed coal seams and causes the release of acids that degrade our surface and groundwater supplies. Soil chemistry is also changed, which then affects plant and animal life. When you hear how cheap coal is, it's because these costs are never figured in."

NUCLEAR FISSION

Without a doubt, nuclear plants are the most controversial electricity generators. Does it make sense to continue to expect energy from this source? As Jay D. Strieb, assistant professor of physics at Villanova University says, "You can make very substantial arguments both pro and con."

The pro side first: Along with coal, oil, and natural gas plants, nuclear plants have proved they can produce large amounts of reliable, affordable electricity. "They're very clean compared to fossil fuel plants and, unlike those plants, they don't use up

Since 1960, American use of electricity has jolted upward by about 150 percent. The culprits? Increased use of home air conditioning and electric heating.

vital resources," says Strieb, "and they provide a huge chunk of our energy supply. We don't know for sure if solar or other alternative technologies will be able to replace them."

We've been spooked by Three Mile Island (the utilities have cancelled 65 plants since the accident) and Chernobyl. But the accident containment system at TMI seemed to work. "It has never been proved that anyone's health was damaged by that accident or by any other U.S. nuclear plant accident," says Strieb. Chernobyl was much more serious. We don't know yet how many Soviets were killed by the explosion, but we do know that the cancer and birth defect rates in the surrounding area have already risen.

Unlike coal, gas, or oil, there is an essentially unlimited supply of uranium—the fuel used in commercial U.S. nuclear reactors. Nuclear plants don't contribute to either acid rain or the greenhouse effect. They do produce radioactive waste, but some experts say the technology exists to safely dispose of it. "For instance, you can concentrate it and then bond it in an epoxy cement material that is basically impervious and has about a 10,000-year life span," explains William Koffke, formerly a power plant engineer and now an assistant professor of mechanical engineering at Villanova. "Then you bury it in more layers of the epoxy, and the waste just gradually decays into harmless material."

On the con side, nuclear-generated electricity isn't all that cheap, opponents say. The cost generally given for most existing units is from 7 to 10 cents per kwh (the amount of power needed to light ten 100-watt bulbs for an hour). That figure—slightly higher but still competitive with coal-fired electricity—is artificially low, detractors contend. Like coal plants, nuclear plants have an operating life of about 40 years, which means that many could end their lives at the same time, within the next two decades or so. But unlike coal plants, which can be refitted with new boilers and other machinery, nuclear plants become radioactive and must be "decommissioned": Either the plant must be sealed up so that radioactive material can't escape, or this material must be disposed of. If decommissioning costs—now unknown—were included in the cost per kwh figure, says Strieb, "nuclear-generated electricity would no longer cost roughly the same as coal-generated electricity."

Although advanced radioactive waste-treatment techniques, such as the one Bill Koffke describes, may be possible from an engineering standpoint, radioactive wastes are usually stored at their home plant because America hasn't yet decided how best to dispose of them. "We've had an ostrich philosophy," Koffke contends. "There were quite a few experiments going on in the late '70s to isolate and stabilize nuclear wastes, but TMI killed all that—people got too scared to talk about it. The Nuclear Regulatory Commission has since just pretended that none of this is a problem. You can handle wastes safely, but only if you admit the inherent dangers and tackle them head on."

Public opinion has made the question of who's right in this argument moot, says Robert Stein: "Building more nuclear plants is obviously not the near-term solution to our electricity problems, because it's not something the public wants right now."

OIL

Cheap supplies of foreign oil account in large part for our tendency not to worry about wasting energy. But with the Middle East as volatile as ever, and Latin American and African oil-producing nations facing both economic and political turmoil, supplies are far from reliable. Nevertheless, Americans are becoming ever more dependent upon imported supplies. The proportion of foreign oil consumed in the United States has jumped from 40 percent of the total at the time of the 1973 oil embargo to 50 percent today.

Meanwhile, domestic production is steadily decreasing. We've used up many of our easily tapped reserves and are now going after deposits that are deeper and harder to pump. And accidents like the Exxon Valdez spill in Alaska have raised public ire against the long-distance transport of oil and the construction of new off-shore drilling facilities.

The electric utilities seem to have taken these facts, as well as federal laws discouraging the building of new oil plants, to heart. They've greatly cut back on their use of oil over the last decade and are unlikely to reverse their course.

NATURAL GAS

Improvements in technology for natural gas exploration and production have led not only to a striking increase in the size of known reserves but also to price cuts that have made this fuel newly competitive with coal. Natural gas contains virtually no sulfur or sulfur compounds, so burning it doesn't contribute to acid rain. And, when gas and coal are burned to produce the

Every nuclear plant ordered since 1974 has been cancelled. And the Department of Energy estimates that a majority of coal-fired plants will near retirement by the mid-1990s.

same amount of electricity, the gas releases one-fifth as much carbon dioxide as does the coal.

Electric utilities haven't ignored natural gas's obvious strengths. The New England Electric System (NEES), one of that region's largest utilities, plans to increase its gas use from next to nothing in 1989 to one-third of its total energy mix by 2008.

But natural gas can't be the whole solution to the electricity supply problem. Even if it pollutes less than other fossil fuels, it does still pollute. And world reserves aren't expected to last much more than 100 years, domestic supplies much more than 50.

HYORO

Electricity generated by water power is clean and doesn't depend on a diminishing reserve of fuel, so it's often floated as an energy-crunch solution. But experts say that U.S. hydro-electricity probably won't ever surpass its present contribution of 10 percent of the total electricity supply. (New England is expecting, however, to purchase about 1,500 additional MW of capacity from the Hydro-Quebec project in Canada, where a number of hydro-electric projects are under construction.) Most of the rivers that could produce large amounts of electricity without disrupting shipping have already been dammed. Recent proposals for new sites have met fierce resistance from both environmental activists and local residents unwilling to see land disappear under water.

SOLAR

Solar power has long been hailed as the solution for most of our energy problems. Yet the sun currently produces less than 0.1 percent of the electricity we use, and that figure probably won't grow much before the next century.

The world's most advanced solar-thermal plant is located in the reliably strong sunlight of the California desert. By harnessing the sun's rays to create steam to drive a turbine that generates electricity, the plant provides Los Angeles with 200 MW at a cost of about 8 cents per kwh. That cost is already lower than for electricity generated by many nuclear plants, and could be even lower if the plant expands. The drawback? Because large amounts of power are always lost when transmitted over long distances, the plant can't supply electricity to areas far from deserts.

Photovoltaic (PV) cells—already used to power watches, calculators, and satellites—convert sunlight directly into electricity. With the electricity costs of the most efficient PV modules hovering around 30 cents per kwh, the process is presently more expensive than solar-thermal generation. But most of that cost is the result of high materials and production costs rather than operating costs.

In Gardner, Massachusetts, the Massachusetts Electric Company (a subsidiary of NEES) installed PV modules onto some house rooftops for free in order to study what happened when they were wired into the existing power grid. WPI assisted in the research by studying the performance of devices that convert the solar cells' direct current electricity to alternating current. Residents found that during the summer months, their electric bills were cut in half. However, if these homeowners had paid for the research, development, and manufacturing costs of their modules (as consumers as a group usually have to pay for the construction of traditional power plants), their bills would have gone up, not down, after the modules were installed.

So, reducing the cost of materials is the goal of most PV research currently under way, according to Pritpal Singh, a PV researcher at Villanova. "We're trying two basic approaches," explains the assistant professor of electrical engineering. "The first is to vary the PV cell's materials in order to capture more sunlight energy, so that you get more electricity out of each cell. The second is simply to find ways to make the cells work using either cheaper materials or a smaller amount of material."

Even if new materials are found within the next few years, as Singh believes they will be, two major hurdles remain. The first is power storage; no matter how efficient solar cells get, they'll never produce electricity at night or on very cloudy days. Although large batteries and other storage methods are being researched, they haven't yet proved to be cost-effective. Without storage, adding more than 10 percent solar-generated electricity to the power source mix could easily result in blackouts, for there would be times when the solar cells couldn't produce enough electricity to meet demand.

The second hurdle is that PV cells—like their solar-thermal counterparts—may never be effective in regions that are frequently cloudy. But as Phil Taylor, professor of physics at Western Reserve College, points out, just because solar technology isn't the solution to all our energy problems is no reason to dismiss it: "Even if we had a small but growing proportion of solar generation in the mix with coal or nuclear plants, it would cut back on our use of those fuels."

OTHER ALTERNATIVES

No one other source even comes close to being able to replace traditional fuels on a large scale. Many of the technologies that depend upon burning such renewable fuels as household waste or wood waste from paper mills present some of the same air pollution problems as traditional fuels. Fuel cells—which chemically convert fossil fuel energy into electricity—are both more efficient and less polluting than traditional burning methods; they emit no sulfur or nitrous oxides and relatively small amounts of carbon dioxide. But although the technology is proven—it worked well enough to help power several manned NASA missions—it is not yet considered cost-competitive with traditional technologies.

Wind turbines are relatively inefficient. Depending on wind conditions, hundreds or even thousands must be built to equal the output of the average traditional plant. Although they don't pollute, they do have a considerable environmental impact. How many people would really want hundreds of five-story-tall windmills to be built atop New Hampshire's White Mountains?

Geothermal technology, which taps heat energy from subterranean hot spots, has already provided over 2,000 MW of energy to northern California. Unfortunately, this method supplies affordable electricity only in areas where such spots are close to the Earth's surface. Ocean-thermal technology, which draws energy from temperature differences in the seas, may eventually provide vast amounts of energy to coastal areas. But that day is far off and research and development is proceeding slowly.

In fact, R&D for all technologies employing renewable sources is proceeding at a snail's pace. That's largely because cheap fossil fuels have made investing in the alternatives unattractive. Meanwhile, the U.S. Department of Energy spending on R&D for renewable energy sources has dropped from nearly $630 million in fiscal '81 to $108.4 million in fiscal '89. That's less than the governments of West Germany and Japan spend on such research. "There's no sense of any problem because energy prices have been so low over the last decade, so there's no feeling that our limited government funds should be pushed in that direction," says Villanova's Singh. And most of the few remaining tax incentives for installing and investing in alternative sources of energy are due to expire this December. That's already killed the fledgling wind turbine industry.

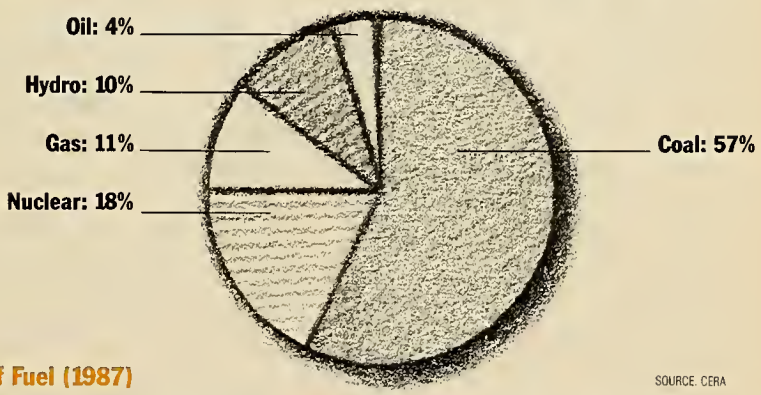
Says Kishor H. Thanawala, a Villanova economics professor who lectures on energy economics, "I think history will record that one of the failures of the '80s has been our shift away from the '70s' focus on alternative energy sources and on conservation. We'll pay for it later."

But at least in some quarters, conservation and efficiency are being rediscovered. In New England, for instance, where electricity supply is especially tight, a novel cooperative arrangement has been hammered out between an environmental advocacy group called the Conservation Law Foundation (CLF) and many of the region's electric utilities.

The arrangement follows a series of lawsuits in which CLF argued that New England could meet 35 to 57 percent of its total electricity needs over the next two decades just by using already proven efficiency measures—without sacrificing either comfort or productivity. What's more, the electricity gained through such measures (dubbed negawatts) would cost only about 6 cents per kwh—2 to 3 cents per kwh less than the cost incurred by building new plants. The bottom line, concluded CLF, is that efficiency measures are a better investment than new plants.

CLF further argued that utilities should pay directly for installing these efficiency measures. The utilities countered that consumers would install money-saving efficiency measures on their own. Wrong, said CLF. High-efficiency light bulbs, for example, cost up to $10, compared to $1 to $3 for the average bulb. Although these high-efficiency bulbs more than pay for themselves over their long lifetimes, monthly electric bill savings seem so small that few consumers buy them. Big commercial or industrial customers have more incentive, because their utility bills are so

Continued on page XVI



Sources of Fuel (1987)

SOURCE: CERA

25 WAYS TO SAVE WATTS

By Lisa Hooker

Yuppies take the heat for everything these days—even for taking too much heat, it seems. Today's yuppies consume 16 percent more electricity than their parents did, according to the Michigan Consumers Power Company. Since 1960, the average U.S. household has increased its electricity use by 150 percent.

Refrigerator/freezers are the number one gobblers of electricity, soaking up 20 percent of the electricity consumed in private homes, according to Cambridge Energy Research Associates. But almost as demanding are the millions of furnaces and air conditioners keeping homes comfortable year-round. On average, heating consumes 19 percent of all electricity used; cooling requires nearly 15 percent of the total.

Environmentalists claim that with a few changes in lifestyle, our electricity consumption could potentially be cut in half. For many people, that would mean an appreciable savings on their monthly electric bill.

What follows is a list of 25 ways to lower your electric bill and conserve energy. Suggestions from experts include, but go far beyond, turning out unnecessary lights. Most of the recommendations don't require costly renovations. Even for those that do, experts say the savings over the life of a home can be worth the expense. Most are common sense approaches to using energy—sense that can add up to dollars in the long run.

Lisa Hooker wrote about groundwater pollution for the Alumni Magazine Consortium last summer.

1 **Bundle up.** Install insulating wraps around your water heater. Particularly during cold weather, water heaters tend to lose heat to the air around them, forcing them to work harder and use more electricity to provide you with showers, clean clothes, and spotless dishes.

2 **Shower yourself with efficiency.** Replace your shower head with one that is more efficient. New ones on the market require less water and less energy to provide you with the same hot shower.

3 **Take time out.** Ask your electric company when peak times of demand occur, and try to use less electricity during those hours. For most areas, peak hours are daylight hours. Do your laundry at night or on the weekend.

4 **Let the sunshine in.** Close your draperies at night and open them during the day to take advantage of the winter sun's warmth. During the summer, keep drapes closed during the day if possible.

5 **Buy the best.** When it's time to shop for new appliances, take a hard look at energy efficiency. The best new refrigerators on the market are at least 25 percent more efficient than the average one in use, manufactured about 10 years ago. The average new air conditioner is 20 percent more efficient. A caveat: Don't be surprised if more efficient models are also slightly more expensive. (For a complete comparison of the energy efficiency of appliances, write the American Council for an Energy Efficient Economy, 1001 Connecticut Avenue NW, Washington, D.C. 20036. They have listings for virtually every appliance on the market.)

6 **Switch off.** Let your electric company know you want to help conserve electricity. Many utilities have programs that allow them (with your permission) to switch off your swimming pool pump on high-demand days or to turn off your air conditioner for 10 minutes every half hour.

7 **Shop smart.** New, efficient light bulbs can cost $10 or more, so they don't look like much of a bargain at first glance. But these long-life bulbs can save $5 or more each year in electricity, and they often last several years. They produce from three to five times more illumination per watt of power consumed.

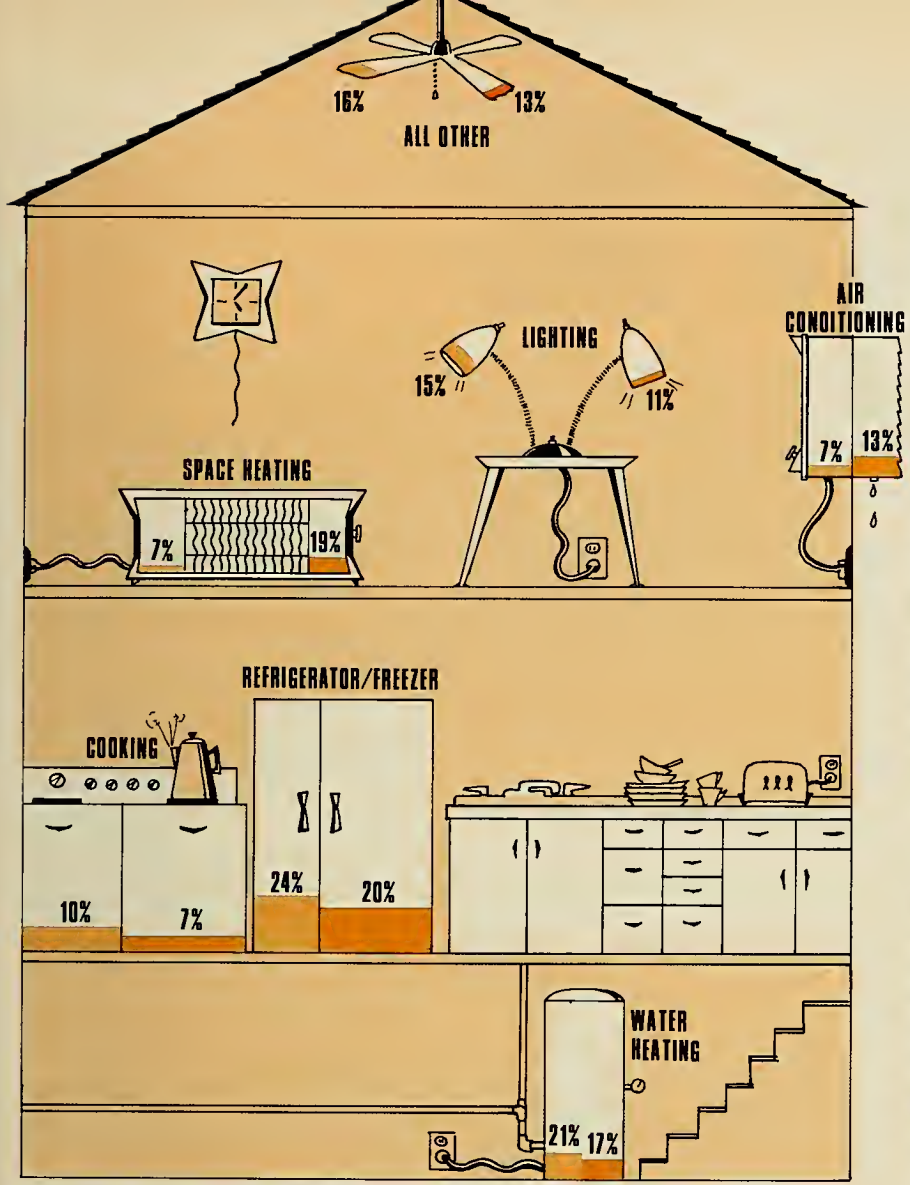
8 **Chill out.** When heating your home, every degree above 68 Farenheit uses 3 percent more energy. Setting your thermostat on 68 instead of a toasty 75 can lower your usage by 21 percent.

9 **Window shop.** If you're building a new home or replacing the windows you have, you can install windows that are at least 50 percent more efficient than those typically used in homes built a decade ago. A leaky house means you're throwing money out the window.

10 **Winterize.** Even if you can't afford new windows, that's no reason to let the air you have warmed at great expense slip through the cracks. Caulk or weatherstrip cracks around the edges of doors and windows. Use clear plastic window insulation kits to keep heat from escaping.

11 **Wash well.** When washing clothes, use only the amount of water you need for the size of the load. Use cold and warm water instead of hot when possible.

12 **Fill the dryer.** When drying clothes, dry a full load. If you must wash small loads separately, wash them first and dry everything together. Also, clear your lint



Keeping the Home Fires Burning required a larger percentage of American household electricity in 1987 than in 1960. However, other uses of electricity took smaller bites of the residential electricity pie.

1960 1987

remover after each load; it helps your machine dry clothes more efficiently.

13 **Unload all lint.** Check your air conditioner filters monthly and change them when necessary. The same goes for furnace filters in the winter.

14 **Look at lights.** Add three-way bulbs in rooms used for several kinds of activities. Use the brightest setting for reading, dimmer settings for general lighting. Use bulbs of the lowest wattage necessary to light each room.

15 **Light is right.** If you're thinking about redecorating, keep in mind that light colors mean lower electric bills. Off-white paint or wallpaper, for example, can reduce the amount of light you need.

16 **Dig out your Thermos.** Before the advent of coffee makers and microwaves, people relied on their trusty Thermos to keep hot drinks hot. Instead of leaving the coffee maker on for hours, dig your Thermos out of the cupboard to keep your coffee warm. Electric gadgetry (like can-openers, toothbrushes, and screw drivers) can be very appealing, but a little elbow grease will save you money.

17 **Check out the attic.** Is your ventilation adequate? If not, you may be using more electricity than necessary to cool your home in the summer. How about your insulation? A properly insulated home can cut your heating costs by a third or more.

18 **Be a conservation fan.** Whenever possible, use fans instead of air conditioners. A window fan uses about one-fifth as much electricity as a window air conditioner, and ceiling fans properly placed boost the work of both heaters and coolers.

19 **Eaves drop.** Install awnings over windows exposed to direct sunlight to keep your house cooler and reduce the demand on your air conditioner.

20 **Zap it!** Whenever possible, use a microwave oven instead of a conventional model. Microwaves cook food in a fraction of the time and use less electricity.

21 **Ban the gawking gourmet.** Keep the refrigerator door closed unless you are ready to remove food. Make sure the door gasket—the rubber strips that hold cold in—seals properly. Also, clean the external coils behind and beneath the refrigerator.

22 **Close doors.** Keep connecting doors to garages, attics, and any unheated rooms closed. Heat—or cool—only the rooms you use frequently.

23 **Buy a humidifier.** If your home is dry, adding moisture may help you feel more comfortable at a lower temperature. But be sure to keep it clean—a dirty humidifier pulls more energy than it should.

24 **Use your dishwasher.** Dishwashers use less hot water than the average family member uses when doing dishes by hand. But operate the appliance only when full. If you rinse dishes first, use cold water.

25 **Last but not least.** Don't forget to turn out unnecessary lights. Be sure television sets, stereos, and radios are turned off when not in use.

For more information about conserving electricity, contact your local utility or call the Alliance to Save Energy, at (202) 857-0666.

Continued from page XIII

large, but efficiency usually isn't considered a sound business decision unless there's a short-term payback. Meanwhile, electricity demand continues to climb, the utilities have to build new plants, and everyone's rates go up to pay for them.

While much of the CLF-utilities partnership program is still at the blueprint stage, some successful efficiency measures are already in place. Since most developers want to hold down construction costs, they usually meet only the efficiency standards set by local building codes. To boost a new building's electricity savings right from the start, NEES provides free technical and design assistance to architects, developers, engineers, and consultants. As further incentive, they help out with the added initial costs of high-efficiency lighting, motors, air-conditioning, windows, heating, and refrigeration equipment.

In Marlborough, Massachusetts, for example, NEES paid the owner of the new Rosewood Development office facility $192,000 to help defray the additional costs of a high efficiency air-conditioning system. By making ice at night to cool water circulated through the building during the day, Rosewood cuts its peak demand by 1,200 kw and saves about $115,000 each year in operating costs. NEES provides similar services to owners who want to retrofit older buildings with more efficient systems.

Energy-saving showerheads, insulating wraps for water heaters, long-life light bulbs—all these are given free to residential customers of the New England utilities working with CLF. The utilities also inform consumers about the most efficient household appliance brands, and tell them how best to maintain and operate appliances and air conditioners.

The program has been so successful that NEES has raised its early targets and hopes to have saved almost 1,000 MW by the year 2008, thereby cancelling the need for about 1,200 MW worth of new capacity. That about equals the electricity output of a large coal or nuclear plant.

But what's in it for the utilities, which have to maintain profits for their shareholders? Says Alan Destribats, "I feel that efficiency is certainly cost-competitive with new generating plants and less expensive than purchasing power from other regions at peak times. Second, we're now working with the regulators so that we can earn an incentive for what we save versus the avoided cost of what we would have spent to purchase this power. So we think it makes good business sense."

Armond Cohen, CLF senior attorney, is glad to hear this and has been helping to work out the rate structure changes: "Our strategy is to make it pay well for the utilities to do good. If it's also in their best interest, there won't be the foot dragging that you see when industries are forced to comply with plans that they see as affecting them adversely."

While encouraging the efficient use of electricity makes sense in terms of protecting the environment and strengthening the nation's economy, such measures aren't always as easy to implement as they might seem, cautions Benjamin Hobbs, associate professor of systems engineering at Case Western Reserve University.

In regions such as the Midwest, which actually has a surplus of electricity at the moment, "negawatts" would replace existing megawatts rather than those produced by new plants. As a result, says Hobbs, "efficiency could lead to a real rate increase, because by law the utilities would be allowed to spread the costs of their existing plants over reduced kwh sales. In Ohio, which is just now recovering from the early 1980s recession, that could injure the local economy."

Consumers and utilities in those regions must look beyond simple cost comparisons and instead balance the costs and benefits of efficiency over the long term, says Hobbs. "For example, weatherizing houses might increase electric bills if consumers are billed higher rates for lower consumption. But the benefit of eliminating cold spots might outweigh the rate increase. In industry, more efficient motors might run longer between maintenance shutdowns. If productivity outpaces rate increases, that's a net benefit."

So which direction should the United States take to ensure a reliable, affordable flow of electricity, as well as a cleaner environment? Energy experts seem to agree that efficiency is the right way to go. It could help keep our products competitive with those of other nations, allow us to hold onto our generally high standard of living, and provide the much-needed time to assess other options.

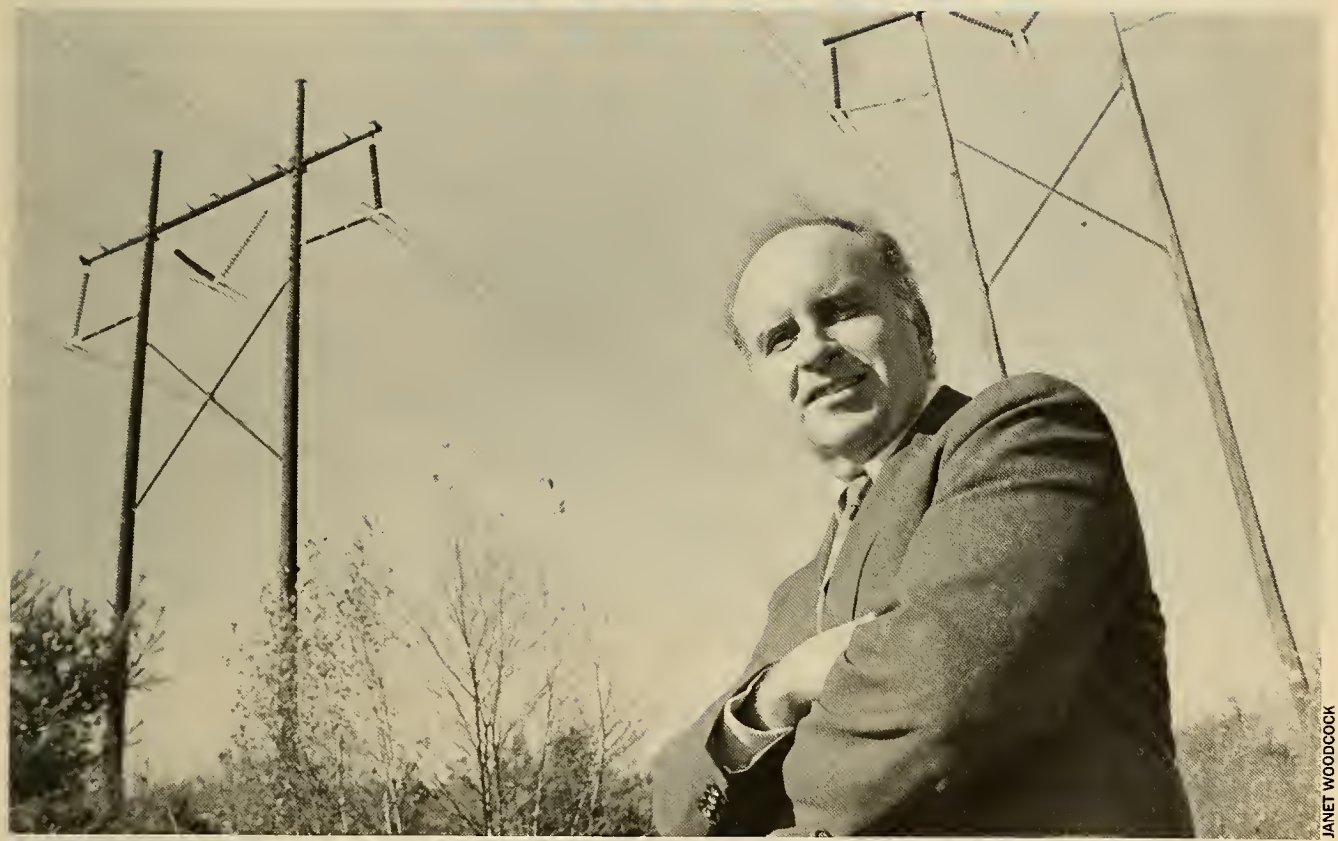
But beyond efficiency? Some experts, like Bill Koffke and Robert Stein, think we need a new commitment to safer, more closely monitored nuclear power generation as an insurance policy in case solar and other renewable source technologies don't pan out. Says Stein, "Nuclear is still the only currently viable technology other than hydro-electricity that doesn't contribute to global warming."

Others think it's time to plow funds into R&D of renewable sources. "How far off this technology is depends on how much money government provides," says Jay Strieb. "Government energy planning has tended to look for immediate results. But these technologies could be long-term solutions to both the energy and the pollution problem."

Still others think that we should re-examine our cost analyses of competing technologies and begin to look at a wider set of costs and benefits. "For example, lumber prices are going up partly because acid rain is causing forest damage," says WMC's Esther Iglich. "But that price is never included in analyses of the cost of reducing power plant pollution, or when comparing coal costs to PV costs."

Most importantly, consumers need to stop taking electricity for granted, the experts agree, and to start thinking about where it comes from, how it gets to our homes and businesses, and how we use—or misuse—it. If we all do that, we're much less likely to face another summer like the summer of 1988.

LIVE WIRES



JANET WOODCOCK

Power systems researcher Kevin Clements uses advanced mathematics to model highly complex electric power networks.

Power systems engineering is anything but a static field for WPI's research group

By
Michael W. Dorsey

When WPI's Atwater Kent Laboratories building was completed in 1907, it was heralded as the first academic building in the United States dedicated to the emerging field of electrical engineering. The building and its equipment represented the leading edge of the discipline. Neatly arrayed in large open bays were massive dynamos, generators, motors, switches and cables—the state of the art in electric power technology. A 40-foot electric trolley test car could be driven right into the heart of the building, which, in a clever bit of symbolism, was laid out in the shape of an "E."

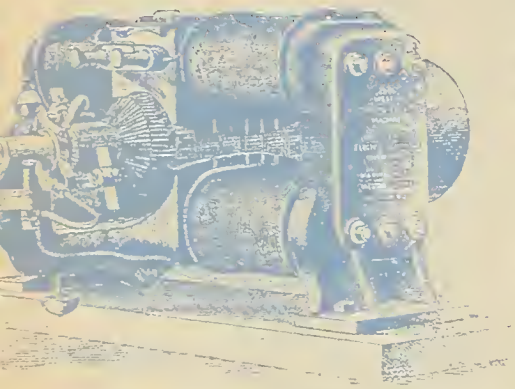
Today Atwater Kent is a very different place. Floors and walls have long since divided the open interior into a maze of offices and laboratories where researchers work on electrical devices wired onto circuit boards or etched in lines finer than a human hair onto chips of silicon. But while much of electrical engineering has been utterly transformed by time, one area—power systems engineering, a field that includes the design and analysis of equipment for the generation and distribution of electric power, as well as equipment that converts electric power into useful work—might seem to have evolved little from those early days.

"That was my perception as an undergraduate," notes Kevin A. Clements, professor of electrical engineering at WPI. "It seemed that there was nothing new going on in electric power. In fact, it wasn't until I came to WPI as a faculty member that I got interested in the field."

What Clements found when he arrived at WPI in 1970 was an active and rapidly changing discipline. Electric networks had grown into vast, highly interconnected spiders' webs of generation plants, high-tension lines, substations and distribution systems, the control of which was taxing the fastest computers. Rising fuel costs

were pushing engineers to develop new and more efficient ways to produce and transmit electricity. Advances in materials, electronics and miniaturization were making possible new and exotic breeds of electric motors and control devices. And, a new generation of power electronics was playing havoc with the smooth, sinusoidal waveform that is the essence of conventional electric power systems.

In short, Clements said, he discovered a field that was responding to challenges that the electrical engineers of 1907 could not even have dreamed of. Today those challenges are tackled by a small group of power systems engineers, a group that has built a reputation that reaches far beyond the bounds of WPI's campus.



Today's power systems group at WPI owes much to the vision of the late Harit Majmudar, a nationally recognized authority on electrical machinery and power engineering who died earlier this year. Majmudar came to WPI in 1964 and served as department head for 10 years. In more than 20 years as a teacher, he inspired hundreds of students to pursue careers in power systems engineering and did much to lay the groundwork for WPI's active research program in the field. In fact, of the four faculty members who form the core of WPI's power systems group, three were hired directly by Majmudar and all say they were strongly influenced by his dedication and love for the discipline.

One of those recruited by Majmudar was Professor Alexander Emanuel, who began his career as a designer of hardware for the electric power industry. By the early 1970s he was working as a research and development engineer for High Voltage Power Corporation in Westboro, Mass.

It was around that time that solid-state devices were beginning to find their way into the power field. Power transistors and thyristors, along with the computers needed to control these new power conditioning devices, were quickly adapted by a wide range of industries.

These power switches made electric motors more efficient by enabling their speed to be varied continuously. While this had always been possible with motors run by direct current (DC), the speed of alternating current (AC) motors is determined by the frequency of the voltage applied to them. Before the advent of power electronics it was virtually impossible to change these frequencies smoothly.

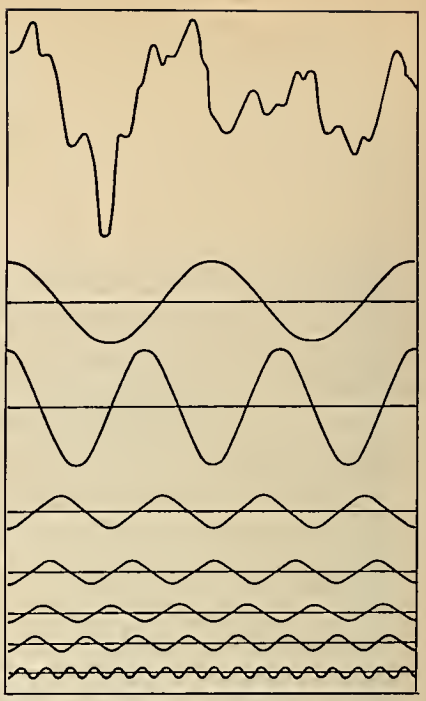
Power electronic devices are essentially switches that can turn on and off hundreds or thousands of times each second (new generations of power switches can operate at radio frequencies, turning on and off hundreds of thousands of times a second). These devices first change the alternating current into direct current, then convert it back to AC at an adjusted frequency. In the process, the smooth sine wave that characterizes the alternating current supplied by electric companies is chopped into a jagged pattern. Using these electronic switches, even motors that churn out several hundred horsepower can be smoothly ramped up from a standing start to thousands of revolutions per minute.

In the latter part of the 19th century, as early electric distribution networks were being built, a debate ensued about the ideal frequency for alternating current. (Unlike direct current, which flows in one direction all the time, alternating current changes direction many times each second. The rate at which the direction of flow changes is called frequency and is measured in cycles per second, or hertz.)

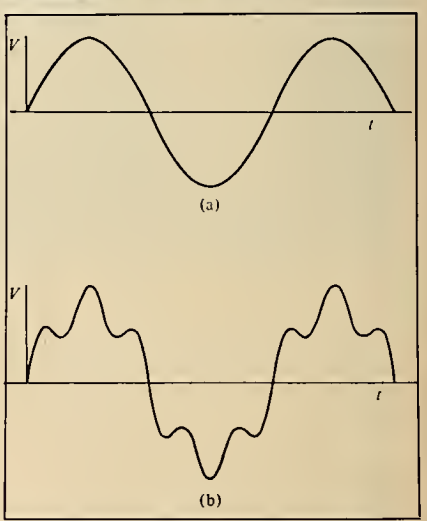
After some experimentation, the designers of early power systems settled on a frequency of 25 hertz, which produced good performance from electric motors. Later 25-hertz electricity was found to produce an objectionable flicker in lamps. Today electricity in the United States is produced at 60 hertz.

Observe the voltage from a typical wall outlet on an oscilloscope and the 60-hertz frequency becomes visible as a nearly perfect sine wave. But when power electronics are in use in an electric system, that perfect curve can be distorted by what power engineers call harmonics.

Harmonics are similar to the overtones produced by the strings of a violin. When a string is plucked it vibrates along its entire length, producing its lowest, or fundamental tone. If a vibrating string is touched in the middle, it vibrates in two segments, each segment producing a frequency double that of the fundamental tone. This higher tone is called the second harmonic. By dividing the string into more and more segments, additional harmonics can be produced.



Top: The harmonic signature of a violin and its component harmonics. Bottom: (a) The smooth sine wave characteristic of normal voltage. (b) The sine wave is distorted by the introduction of the fifth harmonic.



The harmonics on an electric line are multiples of the standard 60-hertz frequency. The strings of a violin often vibrate with several harmonics at the same time, producing the complex tones associated with the instrument. However, when an electric current vibrates with several harmonics, the results can be destructive, according to Emanuel.

"Harmonic currents have many unwanted consequences," he says. "Probably the

JANET WOODCOCK

Alexander Emanuel (center) with graduate students Robert Ashton (left) and Ashim Chakravorti. On the lab bench is work in progress on a harmonic cancellation device.

most common is interference in communications lines," he says. "Harmonics can also produce additional heat in motors and transformers, causing them to age too fast. They can cause electric meters to turn too fast or too slow. In the most serious cases, they have actually caused capacitors and transformers to explode."

While power electronics devices are the most important source of harmonics, Emanuel notes, they are not the only culprit. Industrial machines that draw large, brief surges of power—powerful welding equipment, large motors or capacitor banks, for example—will distort the voltage waveform at the moment they are turned on.

Emanuel refers to this muddying of the standard 60-hertz current as "harmonic pollution." He says it is impossible to remove all harmonics from the voltage waveform, and in fact he notes that levels of harmonics up to 5 percent cause no harm. Above that level, though, the pollution can become a serious problem. As for those consumers who introduce harmonics into the power supply, Emanuel says that, just as with those who foul the air or water, "if you pollute you've got to put money into a solution."

In his laboratory, Emanuel and a team of graduate students are developing solutions that they call harmonic cancellation devices and unity power-factor converters. Working at lab benches packed with meters, capacitors, cables and switches that might not have seemed out of place in Edison's laboratory, Ashim Chakravorti and Robert W. Ashton are developing devices that change the frequency of power in ways that do not produce harmonics.

The idea is to allow the frequency of the power supply to vary, but in a precisely controlled manner. Using specially designed switches, these devices vary the current in a series of rapid zigzags. The zigs and zags are confined to a narrow band that traces out a sine wave with a frequency of 60 hertz. The result is something of a paradox—a power supply that can feed current to an electrical load device at several thousand hertz, but which leaves the 60-hertz sine wave of the power supply harmonic free.

While Chakravorti develops switches for electric motors and industrial equipment, Ashton is working on electronic ballasts for fluorescent lights. To cut energy consumption, a new generation of ballasts has been developed that operate at up to 20,000 hertz. Ashton's ballasts will do the same thing but without generating harmonics.

The potential effects of power system harmonics were understood as early as the 1920s. However, only in the last 10 to 15 years, with the advent of power electronics, have harmonics been recognized as a real threat. Due to limitations in the standard techniques used to sample harmonics, however, it has been difficult to determine exactly how pervasive harmonic pollution is and how seriously harmonics have distorted the average power supply.

Traditionally, harmonics have been measured with a laboratory instrument known as the spectrum analyzer, a cousin of the oscilloscope. With a standard spectrum analyzer, one can sample just one harmonic, of either voltage or current, at a time. Using this device to chart the harmonic profile of a power line can be a tedious and unreliable task.

To solve this problem, Emanuel enlisted the help of John A. Orr, professor and head of the Electrical Engineering Department,

and David Cyganski, professor and vice president for information systems and services. Both researchers had extensive experience applying complex statistical techniques to such electrical engineering problems as signal processing, and Emanuel knew that a robust method for measuring harmonics would have to rely on advanced statistics.

In 1980 Emanuel was working with the New England Electric System (NEES) on a study of the potential impact of electric vehicle battery chargers on the electric supply system. The chargers include power electronics that vary the current as an electric car's battery is charged, providing a high current at the beginning of the charge cycle and reducing the current as the battery approaches a full charge. Since these solid-state switches can generate harmonics, NEES wanted to know whether problems would arise in the future as electric cars become commonplace.

"This is a sophisticated multivariate statistical problem," Orr says. "While you may know how many electric cars are present in a particular town, they won't all be charged every night, nor will their owners charge them all at the same time. Then you must factor in the manner in which the current varies as the chargers operate."

As he attacked that problem, Orr became interested in the problem of measuring harmonics. Recognizing the deficiencies of the standard sampling equipment, he decided to develop a new analyzer. Working with Cyganski he designed a computer-controlled device that can measure up to 15 harmonic frequencies on each of eight different power lines simultaneously.

While the sampling power of the new analyzer was a significant advance, what makes the new device truly revolutionary is its ability to perform statistical analyses, including average value, mean value, maximum value and standard deviation, "on the fly," Orr notes.

"Typically we let the instrument sit in place recording data and calculating statistics for a day, a week or even longer," Orr says. "At the end of the test we can instantly see the results of the analyses in the form of graphic displays."

The system received its first major test during a two-year study of household photovoltaic systems in Gardner, Mass. The study was sponsored by the Electric Power Research Institute and carried out by NEES. In the study, 20 homes were fitted with photovoltaic panels, which convert sunlight directly into electricity. The panels were capable of meeting much of the typical electrical needs of each home; any excess power was fed into the power network.

JANET WOODCOCK

With the analyzer he helped design is John Orr. The device simultaneously monitors up to 15 harmonics on eight different power lines.

Solar panels produce electricity in the form of direct current. To convert this energy to alternating current, one must run it through an inverter, a device not unlike the power switches used to alter the frequency of AC power. Because inverters can generate harmonics, WPI was asked to study the harmonic profile of the distribution lines in the study area.

"The inverters used in the study were high quality and we did not detect much of a problem," Orr says. "That does not mean that in the future, as more homes install solar photovoltaics, or as inverters of lesser quality are put on the market, harmonics from solar panels won't cause headaches."

More recently, Orr, Cyganski and Emanuel used the analyzer to perform a bit of high-tech detective work. The test site was a substation where several high-voltage power lines converge. It appeared that one of the lines was creating interference and possibly inducing hazardous voltages on a nearby telephone cable, but the power company could not determine which cable was at fault without actually taking the lines out of service, one by one.

The WPI team measured the harmonic pattern on each cable and compared it to the pattern of interference being experienced by the phone cable. With these electronic fingerprints in hand, it was easy to pinpoint the culprit.

Currently Orr is using the analyzer to complete a survey of harmonics at a number of substations in New England. The survey will determine how serious the harmonics problem is in the region and will provide data that will help utilities set new operating standards.

While he has encountered isolated problem spots, Orr says "it appears that current levels of harmonics are tolerated well by the network. We don't see the need to set excessively restrictive standards that might prove very expensive. On the other hand, we can see that there are levels not a great deal higher than what we've seen that would be unacceptable."

While Emanuel and Orr see electric power in terms of waveforms on individual power lines, Professor Kevin Clements takes a broader view. His research focuses on the large networks that transport electric power from generating stations to consumers. These systems, which often cover large geographic regions, can consist of hundreds of power plants, thousands of substations and hundreds of thousands of miles of transmission and distribution lines. Controlling such massive systems is a highly complex task—one made more so, Clements says, by changes taking place within the electric utility industry.

"The emphasis in the industry now is on efficiency and security," he says. "The whole nature of the power system is changing because of economic pressures, deregulation and a more competitive environment."

Legislation that requires utilities to buy power from cogenerators, businesses—often private—that produce power only when it is economical, a renewed emphasis on energy conservation and managing utility loads, the rising cost of building new power plants, and increasing public resistance to the construction of new high-voltage power lines have forced utilities to operate power networks "close to their limits," Clements says.

"That makes the whole task of security assessment and monitoring more important and complex than it has ever been," he adds.

Maintaining a secure power network means assuring the system will hold together in the event of a major failure—for example, the sudden shutdown of a generating station or the loss of a major transmission line. Because of the scale of modern power networks, maintaining security can only be accomplished with the help of computers.

"The mathematical model for such a system includes thousands upon thousands of equations," Clements says. "If you want to run the system securely and economically, you have to be able to solve these equations in real time."

Clements is developing ways to solve those equations more quickly. With a $156,000 grant from the National Science Foundation, he is working with Paul W. Davis, professor of mathematical sciences, on what he calls the "front end state estimation problem."

In essence, solving the problem requires developing a computer model that can quickly deduce the current state of the system from information provided by thousands of data points that reach the power network's central control center. This data includes information about the output of power plants and the instantaneous load on power lines, substations and transformers.

Moreover, the model must help system operators determine the best course of action—which power generators to bring online and which to keep in reserve, which power lines to use to route power here and there, and, when things get tight, how to juggle all the components to keep the system running smoothly. Adding to the challenge, the model must enable the operators to supply electricity to customers as economically as possible.

"This is a very difficult, nonlinear optimization problem," Clements says.

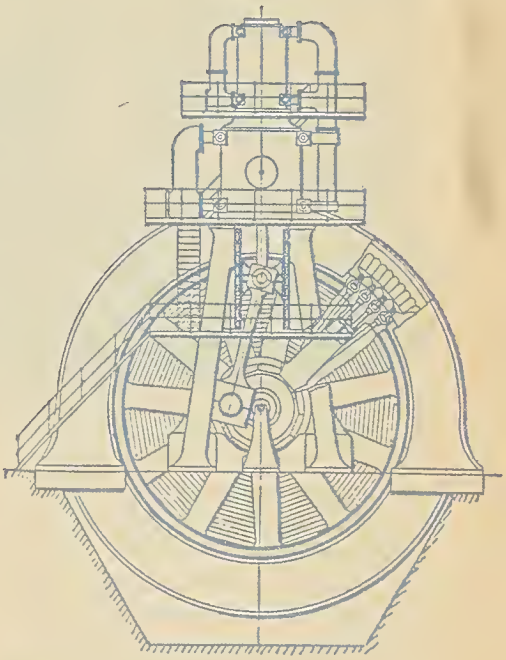
He spent the 1988-89 academic year on sabbatical at the University of California at Berkeley learning more about new approaches to solving just such problems. One pioneering approach was discovered in 1984 by Narendra Karmarkar of AT&T Bell Labs. Karmarkar used interior point methods—so named because they explore solutions that are interior to the problem constraints—to route telephone calls nationwide and to schedule crews for commercial airlines. His methods solved these problems much faster than could existing techniques.

After studying interior point methods, Clements spent six months as a consultant applying these techniques to the problem of optimizing electric power networks. "This was a very difficult problem to solve with earlier methods, which often could not find a solution or took hours to do so," says Clements. "Our new algorithm will find a solution if one exists and will find it at least an order of magnitude faster."

The algorithm has been developed into a commercial product by a consulting firm and should prove quite popular with utilities, he says.

Currently Clements is exploring the application of new developments in computer science—such as parallel processing, neural networks and artificial intelligence—to power system problems. These techniques may speed up his models and enable them to better sort through the vast amount of data that flows into a power network control center, focusing only on the data that really matters.

"Modeling is an art," Clements says. "The real world is infinitely complex. At some point you have to idealize your model. In a power system, for example, you have many things happening at the same time, all at different rates. Some things, like a boiler in a power plant building up steam, happen slowly. Other things, like surges on power lines, can happen in microseconds. It's impossible to model everything and still get an answer in a reasonable amount of time."



David A. Torrey is alone among the members of the power systems group in looking strictly at what lies at the end of the power line—devices that translate electric energy into mechanical work.

Electric motors today consume about two-thirds of all the electricity produced in the United States. They are found in everything from kitchen appliances, to the industrial machinery used to assemble those appliances, to the electric trains that carry them to market. It's not surprising that a great deal of attention has been paid to making electric motors more efficient.

Because AC motors are less expensive, more reliable and, pound for pound, more powerful than their DC cousins, they are used in most industrial applications. AC motors fall into two broad categories: synchronous and asynchronous machines. Both types derive their power from the interaction between a rotating magnetic field in the stator (the stationary part of the motor) and a separate magnetic field in the rotor (the part that spins). The rotating magnetic field is created when two or more AC phases (a phase is a separate source of electric power; most AC generators produce three phases) are applied to windings

JANET WOODCOCK

David Torrey tests the drive unit for a new variable-reluctance motor. This new generation of electric motors requires sophisticated electronics to operate.

in the stator. The speed at which the field rotates is determined by the frequency of the electricity.

Torrey's interest is in a new and highly efficient type of synchronous machine known as the variable-reluctance motor. The motor has many poles arranged like magnetic teeth around its stator. Wire from several separate phases is wrapped around the poles and when the wire is energized, magnetic fields are set up that push and pull the magnetized rotor around in a circular path.

"In a sense, it's the oldest type of electric machine," Torrey says. "It works on the principle of electromagnetism. You turn the current off in one phase and step the rotor around by applying current to the next set of windings. If you do this fast enough, you get continuous rotation."

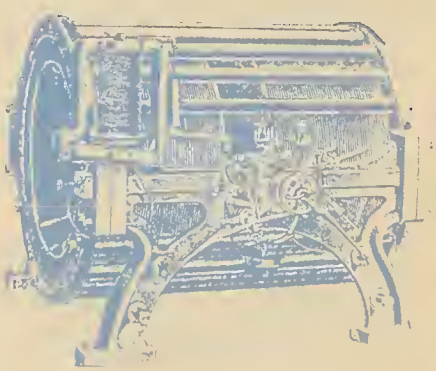
The principles of the variable-reluctance motor have been known for many years. However, it has only been in the last decade or so that the electronics needed to switch the current on and off rapidly and precisely enough, as well as newer machining techniques precise enough to make the rotor and stator conform to very fine tolerances, have emerged.

Among Torrey's current projects are a set of small motors for the Eastman Kodak Company and a 700-horsepower motor that he has proposed to the U.S. Navy. Both projects present special challenges. The Kodak motors must produce torque in a smooth, even fashion—something variable-reluctance motors do not do well. Because they create power by giving the rotor a series of magnetic pushes, their power output is characterized by ripples. To smooth out the ripples, Torrey says he may add more individual phases to the motor. Since each phase is like a hand pushing on the rotor, more phases will mean more hands and a smoother ride for the rotor.

The Navy project will require Torrey to push back a barrier known as power density, or the power output per pound or square inch of motor. Near his desk Torrey keeps a pattern that shows the shape of the stator and rotor of an 80-horsepower motor he designed. The motor, which has the same power output as a compact car, is less than a foot across and about one foot long. The motor Torrey will build for the Navy, a package not much more than half again as large, will be 18 times more powerful.

"The power density of that motor will be phenomenal," he says.

The motors themselves are just one part of a system that also includes the power electronics that drives the motor and the microelectronic control devices that turn the individual phases on and off in a delicate ballet that keeps the motor turning. Torrey says all of the elements of the system must be designed to work together to produce a highly efficient motor.



"I try to find the appropriate combination," he says, "so I can simplify the motor design as much as possible and simplify the power electronics as much as possible, while still meeting the design objectives."

In addition to making these high-tech motors run efficiently, the electronic control systems can also monitor the performance of the motors and probe their health. By measuring the voltages and currents on each of the motor's phases, one can determine—to one part in 50,000—the position of the rotor and, therefore, the position of anything attached to the rotor (a robot arm, for example).

The voltages and current levels can also provide an early warning of problems in the motor or problems with the machinery the motor is driving. For example, a failing fan blade may show up as a high voltage on one of the motor's phases. With proper programming, the motor controller can also adjust the current and voltage delivered to the motor to compensate for changes in the machine's performance due to wear. They can even adjust for the way the heat of an operating motor changes the conductivity of the copper in its windings, Torrey says.

These features have been put to use in a variety of sophisticated machines, including the latest generation of jet fighters. In the design of many new fighters, control surfaces once operated by hydraulics are now powered by electric motors. When variable-reluctance motors are used in these so-called "fly-by-wire" systems, the motors monitor their own position, eliminating the need for separate sensors, and also provide pilots with advance warning of motor failure.

In the years ahead, developments in motor design, as well as advances in most areas of power systems engineering, will be driven by the relentless push in electrical engineering to make things smaller and faster. Already, Torrey says, work is under way on motors that can be etched onto chips of silicon, much as integrated circuits are now made. These tiny motors might be used to dispense drugs inside the body.

"We're seeing revolutions in many areas," Torrey says. "There's certainly no shortage of opportunities for anyone interested in this field."

The Oldest Living Graduate: Sumner Davis '08 is a Hale and Hearty 104

By Ruth Trask

BILL WELLS

Sumner Davis '08 enjoys a game of solitaire as daughter Jane Davis (standing) and a researcher from the University of Kentucky look on.

A former WPI track star, Sumner Davis '08 may have slowed down a bit since his days on the Hill, but he's still chalking up records. According to the college's files, the 104-year-old Davis, a classmate of rocket pioneer Robert H. Goddard '08, is WPI's oldest living alumnus.

"And he's going strong," says his daughter, Jane Davis, who keeps an eye on him in their Lexington, Ky., home. "Although he's now confined to a wheelchair and is hard of hearing, my father continues to live quite independently. He enjoys watching TV, solving word puzzles and playing solitaire. And he eats whatever he likes."

Father and daughter were recently visited by an interviewer from the University of Kentucky who wanted to know the secret of Sumner's longevity. The interviewer was compiling information for a study of the state's centenarians.

"There was so little information available about people of this age, we wanted, first, to describe them accurately," explains David Wekstein, associate director of the university's Sanders-Brown Center on Aging and director of the centenarian project, in a story in the University of Kentucky research magazine. "Our goal was simply to find out what 100-year-olds in Kentucky had in common."

"We explained," says Jane, "that my father comes from strong Pennsylvania stock." Many of Sumner's forebears lived active lives well past 80. The potency of that genealogical "stock" came to the fore a few years back when he had a serious operation, his daughter remembers. As soon as he came out of the anesthesia, he requested a calculus book. The request granted, he opened the book, studied it for a bit, then smiled with relief. "Well," he said, "I can figure out the problems. My head, at least, is still intact."

Inner strength, intelligence and a keen

WPI's 1908 track team. Sumner Davis is second from the left, bottom row.

sense of humor have helped Sumner Augustus Davis weather life since the day he was born on January 28, 1885 in Jermyn, Pa. He began his schooling at home and entered the public schools in third grade. While in high school, he took correspondence courses in mechanical drawing.

Davis went to work for the Carbondale Machine Co. in Carbondale, Pa., as a draftsman with the feeling that he "knew it all and that further education was unnecessary," he wrote in a 350-page book he published in 1973. The book documents his family tree since 1599. "I soon learned that my education had barely begun." With the aid of a phonograph course in French, he passed the entrance examinations at WPI and enrolled in 1904. While at WPI, Davis was a member of the Theta Club and a sprinter on the track team.

"1908 was a poor year to graduate [as far as getting a job was concerned]," he wrote in his book, "so for a time I sold books in Harrisburg, Lancaster, York and Williamsport, Pa., finally getting a position as draftsman with the Scranton Electric Co., which I resigned after a time to accept a better offer with the United Shoe Machinery Co. in Beverly, Mass. Davis and his first wife moved to Athens, Ala., where he purchased a lumber business with his brother-in-law and operated the Athens Planing Mill Co. until it was destroyed by fire in 1917. During World War I he worked for the J.G. White Engineering Co.

"I was equipment supervisor at the construction of the huge steam generating plant prior to construction of the Wilson Dam on the Tennessee River," he remembers.

"Among the first to join, and one of the last to leave this construction," he recalls, Davis was appointed city clerk in Athens. Later he joined J.H. Perkins, consulting engineers, on an inventory and appraisal of the Birmingham Railway, Light and Power Co. in Birmingham, Ala. "When the appraisal was completed," he says, "I remained with the company as draftsman and later as supervisor of the engineering department, retiring at 65, following 30 years of service."

After retirement Sumner served the company as a consultant. Subsequently he became a bookkeeper for his son, Dr. Sumner Danforth Davis, and retired for the second time, at age 90, following his son's death. A number of years ago, he was an admissions counselor for WPI.

That type of commitment has characterized Davis throughout his life. He is, for example, one of the longest serving scoutmasters with the Boy Scouts of America. He has been affiliated with the B.S.A. for more than 50 years.

"I became active in scouting as an assistant scoutmaster in 1923 in Birmingham, Ala., through the inducement of my then 12-year-old son," he says. Later he was a scoutmaster, secretary and president of the Scoutmaster's Association, organizer of the first Pine Tree Patrol in Alabama, organizer of the first Boy's Life Troop in Birmingham, scoutmaster of the Scoutmaster's Training School and a member of the Birmingham Council B.S.A.

In 1928 he organized his pride and joy, the Sea Scouts (a forerunner of the Explorers) in Birmingham. "It was the first Sea Scout troop in the South," Davis reports. The project was particularly ambitious, considering that Birmingham isn't especially close to any large body of water. The troop met inside a church with a room designed like a fully rigged ship.

"The boys sat around a gunwale and I drilled them on everything from tying knots to reading navigation charts," Davis says. His Sea Scout troop acquired a 16-foot cutter with 10 oars, practiced on the Warrior River, and won the national Sea Scout Flagship title in 1930. Davis, who could never swim a stroke, said that his chest swelled with pride when he was named regional vice commodore.

In 1933 he won the Silver Beaver Award "for distinguished service to boyhood," the highest scouting honor the Boy Scouts bestow on an adult.

Many of his scouts went on to high positions in the military and industry. During World War II, Davis kept in touch with former scouts serving overseas with a newsletter called "The Dixie Propeller."

He once told a newspaper reporter about the time one of his former scouts, an Air Force colonel, took him on a demonstration flight in a two-seater plane. "He flew me upside down," he recalled. "Not many people fly upside down. That's something to talk about."

Besides scouting, Sumner's hobbies have included stamp collecting and music. Especially music. For many years he played the saxophone in the Birmingham Shrine Band, which performed all over the U.S., Mexico and Canada. He also appeared with numerous other Masonic bands, and with various amateur and professional dance orchestras. In addition, he was active as a deacon with his local church.

In his 75th year Davis took a memorable four-month trip into the interior of the Belgian Congo to visit daughter Jane, who was a medical technologist at a large mission hospital there at the time. The report of his odyssey appeared in a 1960s issue of the *WPI Journal*. Davis described his ocean crossing on a freighter and his many adventures along the coast of Africa as the freighter unloaded its cargo of oil, foodstuffs and machinery. After arriving in Matadi, the Congo's river port, Davis headed into the interior of Africa—"miles and miles by rail, air, river steamers, trucks and dugout canoes."

The Congolese, who Davis says looked old by the age of 50, wondered why he was not in a wheelchair. While roaming the countryside, he marveled at the unusual wildlife. Once while driving in the Congo he noticed lines of driver ants crossing the road.

"When these drivers enter a missionary's home the people generally let them take over for a day or so and move in with a neighbor," he was told. "When the ants leave, a thorough house-cleaning has been done as far as roaches, bugs and other vermin of any kind are concerned."

Today, Sumner and Jane live quietly at their Kentucky home with frequent visits from his other daughter, Olive Pierce, who lives in Birmingham, Ala. Jane confides that their father still occasionally admires the ladies.

"Octogenarians?" she is asked.

"Oh, no," she replies quickly. "Ladies under 50!"

MEMORY BANK

Those Championship Seasons

All true WPI sports enthusiasts can easily name the college's undefeated football teams. They were, of course, the teams of 1938, 1954 and 1983. But how many know about the "game heard 'round the world," as it will always be known?

The year was 1944. The world was at war. WPI, like the other colleges with which it could still schedule games, was able to continue athletic competition because of its participation in military educational programs such as the Navy V-12 program.

That season the WPI football team traveled to Cambridge to face the highly favored Crimson team of Harvard University. The media viewed it as a David and Goliath event. But the next morning's headlines read, "Worcester Tech 12, Harvard 0." The Armed Services News Network flashed the news to servicemen around the world, including many WPI alumni.

The popular Boston sports writer Bill Cunningham wrote that Harvard dismissed the significance of the upset, noting that football at Harvard in 1944 was "informal." Continued Cunningham, "At Worcester Tech, football has always been informal."

WPI sports history is replete with such memorable events. When the late Edwin F. Hatch '37 set the school record of 21.6 seconds in the 220-yard dash, he had no way of knowing that he would become a sports immortal. His name will be listed next to this event as long as the wooden record board hangs in Alumni Gym.

"Others came within a tenth of a second of Hatch's record, but no one tied it," remembers WPI track and field coach Merl Norcross. "Now the event is no longer run since track events have shifted to metric distances." For the same reason Sidney Stayman '44 and Tom H. Fieldsend '74 will forever remain tied for the school record for the 100-yard dash.

Women athletes have set impressive records since the early 1970s. The women's fencing team, which didn't have a regular coach, beat defending champions from Brandeis in 1973 to become the first WPI women's team to win a championship.

The reason for the team's success? At the time, it was reported that the women learned the sport by practicing with the men's team, which might have given them a competitive edge. That championship team included Peggy Moriarty Staruk '78, Elizabeth Ronchetti '74 and Holly Keyes Ault '74. Holly Ault is now a member of the faculty of the Mechanical Engineering Department.

Another WPI sports spectacular was described in the June 3, 1974 issue of *Sports Illustrated*. "When the news reached Worcester (Mass.) Polytechnic Institute that the school's bowling team had won the Eastern Intercollegiates, the reaction was instant and unanimous, 'What bowling team?' the magazine reported.

"The ragtag outfit ran into heavy competition—sartorially that is. All the other teams were outfitted in natty uniforms and some even had coaches. The Technicians merely had this little knack with the ball. They won the team title going away, the first national championship for the school in 108 years. What bowling team, indeed!"

Those championship bowlers were Gary M. Anderson '76, Thomas I. Burns '74, Randall S. Emerson '76, Gary M. Gastiger '74, John T. Germaine '76 and Edward J. Karedes '75.

Sports Illustrated notwithstanding, WPI's first national champion was Harry Dadmun of the Class of 1891. After setting school records in distance running events that stood for nearly 40 years, Dadmun won the national championship in the half-mile run in 1890 in Washington, D.C. He later won the A.A.U. championship and the French National Championship.

"In his retirement years, Harry Dadmun used to come to every home track meet at WPI," coach Norcross recalls. "I met him a couple of years before he died. He'd talk about the old days and together we'd assess the current team. I used to drive him home after the meets. I'm proud to have had the chance to know him."

WPI's most recent national individual champion is Eric J. Meerbach '87, who won the national NCAA Division III golf championship in Exeter, Pa., in 1986. "Eric had only played six matches that spring, compared to the 20 or so that most of his competition had entered," recalls WPI golf coach Mel Massucco. "I believe he was the only New Englander to ever win this event. Most national collegiate golf champs come from parts of the country where they can play all year long."

If you have other memories of great moments in WPI sports, we'd like to hear about them. Just drop a note to the editor.

—Roger N. Perry Jr. '45

NCAA Division III golf champion Eric Meerbach '87.

EXPLORATIONS

The Superfund SITE Program: Afloat or Floundering?

JANET WOODCOCK

From left, Selby, Calarese and Petkers. Their project recently earned WPI's President's IQP Award as one of the two best Interactive Qualifying Projects of the year. The project pointed out ways the EPA can improve its Superfund SITE Demonstration Program.

Interactive Qualifying Project completed at the Washington, D.C., Project Center by James W. Calarese '90, Michelle D. Petkers '90 and Stephen E. Selby '90.
Advisors: Dieter Klein, associate professor of management, and Richard D. Sisson Jr., professor of mechanical engineering and director of manufacturing engineering.
Sponsor: Library of Congress, Congressional Research Service.

From the Love Canal neighborhood near Buffalo, N.Y., to an 80-mile stretch of Mississippi riverbank dubbed "cancer alley" by residents, toxic-waste dumps, polluted rivers and poisoned wells dot the American landscape.

Congress created the Superfund in 1980 to help finance the enormous cost of cleaning up the nation's hazardous waste dumps. Six years later Congress authorized the U.S. Environmental Protection Agency (EPA) to establish the Superfund Innovative Technology Evaluation (SITE) program to promote the research, development and demonstration of new waste treatment technologies—technologies that will be needed to effectively wage an all-out war on hazardous waste.

The task of the SITE program is to test new waste cleanup technologies at actual waste sites. The program is also intended to help demonstrate that these technologies actually work, overcoming the obstacles that sometimes stand in the way of getting new and untried technologies into use.

To find out how well the demonstration portion of the SITE program has worked, Calarese, Petkers and Selby interviewed officials in industry and at the EPA.

As Superfund nears its 10th birthday, most observers agree that it has been a disappointment. In February 1989, *U.S. News & World Report* noted that of the more than 1,000 hazardous waste sites on the Superfund priority list, only 43 had been cleaned up. The SITE program has also been criticized because of its apparent slowness in testing new technologies.

Overly stringent program requirements, and the procedures the EPA uses to match technologies to be tested with appropriate test sites, have combined to slow the process down, the students report. Insufficient EPA funds for the tests and problems with some of the contractors used by the agency were cited by some survey respondents as additional weaknesses.

The students made several recommendations they say could improve the effectiveness of the SITE Demonstration Program. While they noted that little could be done to streamline the program requirements, there are ways to improve the site matching process. For example, creating a database of suitable sites could help speed the selection process. They also recommended that the EPA select several sites at which a number of technologies can be tested concurrently.

Their other recommendations include better screening of contractors, hiring only one contractor for each demonstration, and establishing a communication system among those doing sampling and analysis at the demonstration sites to prevent delays and mistakes.

"Although the SITE Demonstration Program is progressing more slowly than first envisioned, [it] is beginning to accomplish the goals the EPA has set," the students wrote. They recommended that Congress continue the program.

In its own reviews the EPA has arrived at similar recommendations, some of which—for example, the creation of a computerized database of demonstration sites—are currently being implemented, says Mary Tiemann, an analyst in the Environment and Natural Resources Policy Division of the Congressional Research Service.

The students' report has been provided to the House Committee on Science, Space and Technology for its use in reviewing the SITE program. "While it is too early to say what will come of the students' recommendations," says Tiemann, "the report has generated some communication on this issue between the EPA and the authorizing committee involved in studying the SITE program. Anytime you open up the lines of communication you benefit."

A Surprising Look at British Engineers

Interactive Qualifying Project Completed at the London Project Center by Steven L. Anderson '90, Matthew L. Carpenter '90 and Christine M. Hajjar '90.

Advisor: James S. Demetry, professor and associate head, Department of Electrical Engineering.

Sponsor: Great Britain's Institution of Electrical Engineers.

Anderson, Carpenter and Hajjar studied the career concerns of mature engineers (age 40 or older) in the United Kingdom. In particular, the Institution of Electrical Engineers (IEE) hoped to learn what measures could alleviate engineering manpower shortages facing British industries and universities. The students' report was submitted to Britain's Government and Engineering Council.

Great Britain did not always have problems attracting and keeping engineers. During the Industrial Revolution the nation's focus was on technological advancement; by 1850 it was a world leader. During the next 130 years, however, anti-industrial attitudes that first surfaced during the reign of Queen Victoria led Britain away from capitalism and technological development toward socialism and an anti-technology spirit.

During this period, occupations associated with industry and technology increasingly came to be considered ungentlemanly. Educational institutions directed their curricula more toward the liberal arts, with a consequent decline in the number and quality of bachelor's and master's degrees awarded in engineering. Partly as a result of these changes, by 1980 Britain's per capita gross national product fell to 14th among the world's nations.

The major career concerns of mature engineers in Great Britain include their perceived lack of status, age discrimination and the need for more continuing education and training, Anderson, Carpenter and Hajjar found. They noted that these and other problems might be alleviated if the IEE and others involved in engineering adopted several strategies:

—Pushing for legislation that would make age discrimination illegal in Britain. Companies can now legally specify an "upper age limit of 40" in job postings—according to a recent survey, 88.5 percent used the phrase in their ads.

JANET WOODCOCK

Anderson and Hajjar studied the career concerns of mature British engineers.

—Increasing public awareness of the role engineers play in British society.

—Promoting engineering among British youth through field trips and lectures.

—Redefining engineering to improve society's perception of the profession. The British use the term engineer to refer to tradesmen, such as electricians, mechanics and plumbers, as well as professional engineers. The students believe the definition should be limited to "those who apply scientific knowledge to the solution of complex problems."

—Publishing a handbook of continuing education courses, seminars and workshops and encouraging universities to improve their offerings for engineers.

Alcohol Use in Ireland and Massachusetts

Interactive Qualifying Project completed through the Ireland Project Program by Pamela M. McNeil '91, James J. Fraser '90, Christopher G. Dusseault '90 and Timothy R. Membrino '90.

Advisor: Susan Vernon-Gerstenfeld, director of the Ireland and Washington Project programs.

The students examined the development and evolution of alcohol control policies in Massachusetts and Ireland from 1950 to 1988 in cooperation with Dr. Joyce O'Connor, director of the Social Research Center at the University of Limerick. In addition to a thorough literature search and historical review, they interviewed experts on alcohol policy development on both sides of the Atlantic.

Differences in culture and politics, they found, play an important role in alcohol consumption. For example, the Irish, viewing the consumption of alcoholic beverages as an important part of the Irish culture, are highly tolerant of those who drink, believing in lenient alcohol control policies and enforcement. In contrast, Massachusetts residents are far less tolerant of alcohol use and abuse and generally support strict alcohol control policies as reasonable means of controlling consumption.

Alcohol-related legislation in Massachusetts includes "Operation Last Call," which prohibits establishments from serving alcohol to intoxicated patrons; a law requiring judges to suspend the driving license of any driver with a blood alcohol level of 0.10 percent or higher as measured by a Breathalyzer; a legal drinking age of 21 (raised from 18 in 1983); and regulations that require anyone wishing to purchase alcohol to show proof of age.

The students noted that in Ireland people are less concerned about the increasing consumption of alcohol among women and young people (there are no age restrictions for drinkers) and are more accepting of alcohol-related work absences and automobile accidents.

However, things may be changing in Ireland, they found. Recent discussions among legislators have focused on lowering overall alcohol consumption through the use of identity cards, alcohol-free social events, restrictions on the number of hours alcoholic beverages may be sold and the licensing of establishments that serve these products. Most of the legislation appears to be directed toward reducing the number of young drinkers.

—Bonnie Gelbwasser

On the Irish coast are Membrino (seated) and, from left, McNeil, Dusseault and Fraser.

FINAL WORD

Solar-Powered Science at the Top of the World

The Himalaya Mountains have been called the "top of the world." This remote corner of the globe might seem like an odd place for an experiment in solar energy. Still, it was here that a team of physicians, scientists and students recently made an unusual contribution to the history of solar photovoltaics.

The team came to the Warwan Valley in northern India to study the health, housing conditions, and agricultural resources and practices of 150 villagers living there. They brought along computers to record and analyze their data. But, far from the nearest electric socket, they turned to solar energy to power their computers, becoming among the first researchers to use solar-powered computers to collect and analyze their data in the field.

This milestone in scientific research was made possible by the ingenuity of three WPI students, according to Dieter Klein, associate professor of management at WPI and a member of the 22-person research team.

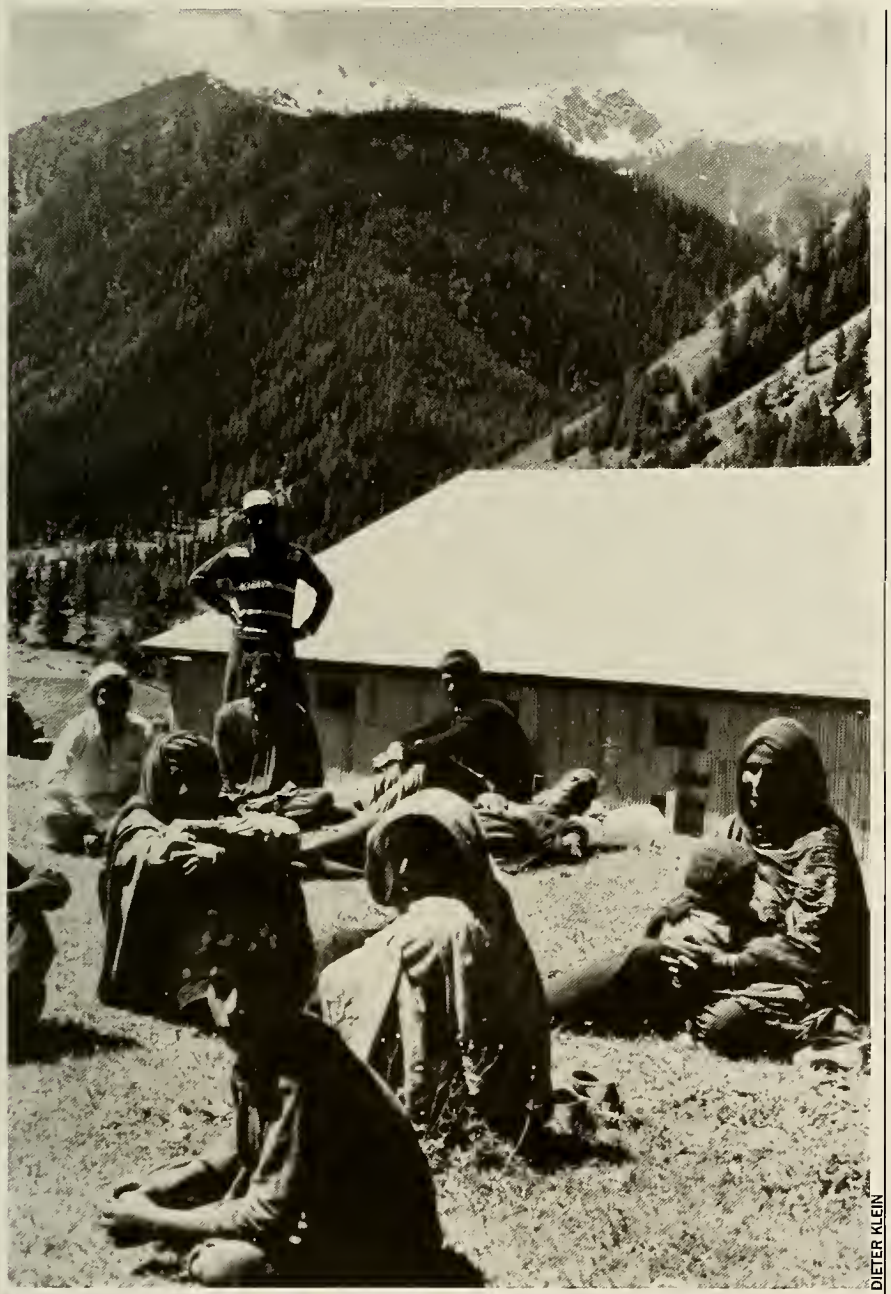
Klein's research interests focus on the use of Information Age technology in the administration and application of health care in developing countries. Last spring, when he became a member of the Himalayan research team, he asked Hewlett-Packard Corporation to provide computer equipment for the expedition. Hewlett Packard responded by donating two HP 110 Plus portable computers, including appropriate spreadsheet and word processing software. But, if the computers were to prove useful in the field, Klein knew he had to find a solar-charged power supply for the equipment. Klein turned to WPI student Stephen B. Trier '90, who, with Raymond S.F. Chin '89 and Timothy S. Storey '89, had earlier designed a solar-powered battery eliminator. The trio were the recipients of WPI's first Class of 1975 Award, which provided the financial support they needed to develop the battery eliminator as their Interactive Qualifying Project (IQP).

Trier, Chin and Storey not only designed and built a working prototype, but in October 1988 founded their own company, Soltaics Engineering Inc., to manufacture and market the solar devices, which can be used for such consumer electronics as radios, portable televisions and emergency lighting, as well as computers.

Far from the nearest outlet, Dieter Klein runs his computer with solar power.

Last winter their success was recognized by WPI, which presented the three students with the Robert H. Grant Award for outstanding achievements by student entrepreneurs. More recently, the students were named Entrepreneurs of the Year by a Worcester-area business magazine.

Storey, who is vice president and direc-



DIETER KLEIN

Residents of a Himalayan village wait to talk to health care researchers.

tor of engineering for Soltaics (Trier serves as the company's president and treasurer, while Chin is vice president for sales and marketing), designed the electronic circuitry for a solar battery charger that met Klein's needs. The unit is unbreakable, waterproof and small enough to fit into a standard computer carrying case.

With the power supply in hand, Klein and the rest of the research team set out to complete the Himalayan project, which was sponsored by the State University of New York at Buffalo and the Sher-I-Kashmir Institute of Medicine in Shrinagar, Jammu, and Kashmir, India. Richard V. Lee, chairman of the Department of Medicine at the Children's Hospital of Buffalo and professor of medicine and pediatrics at the State University of New York at Buffalo, served as team leader.

"The project is part of a research study on the health status of isolated and ecologically stable populations," he says. "This is the fourth year a team has traveled to Kashmir to evaluate the residents' growth and development. The research dates back to 1972 in South America and Asia."

Lee says the researchers have learned, for example, that the people of the Warwan Valley are one of the few populations in the world that has never been exposed to the AIDS virus. Also the natives, whose diets are high in salt, have blood pressure levels comparable to North Americans, as compared to the lower blood pressure levels of Africans and South Americans, who consume less salt.

"The purpose of the study is to establish a record of the health status and disease progression as these isolated villages become exposed to modern civilization through roads and tourism," says Klein. "The information is helpful for training medical personnel and designing programs for the improvement of health in these areas.

"This project indicates how much can be accomplished when education, medicine and industry work together," says Klein. "And, it demonstrates clearly that small computers can be used in remote areas, and that their capabilities are available to solve local problems such as early detection of potential epidemics. Computers can also help detect deterioration in health and provide better information to regional governments for the planning and administration of appropriate programs."

Klein says he plans to use the computer equipment during his upcoming sabbatical year, when he will study the applicability of microcomputers for health care in developing countries.

—Bonnie Gelbwasser

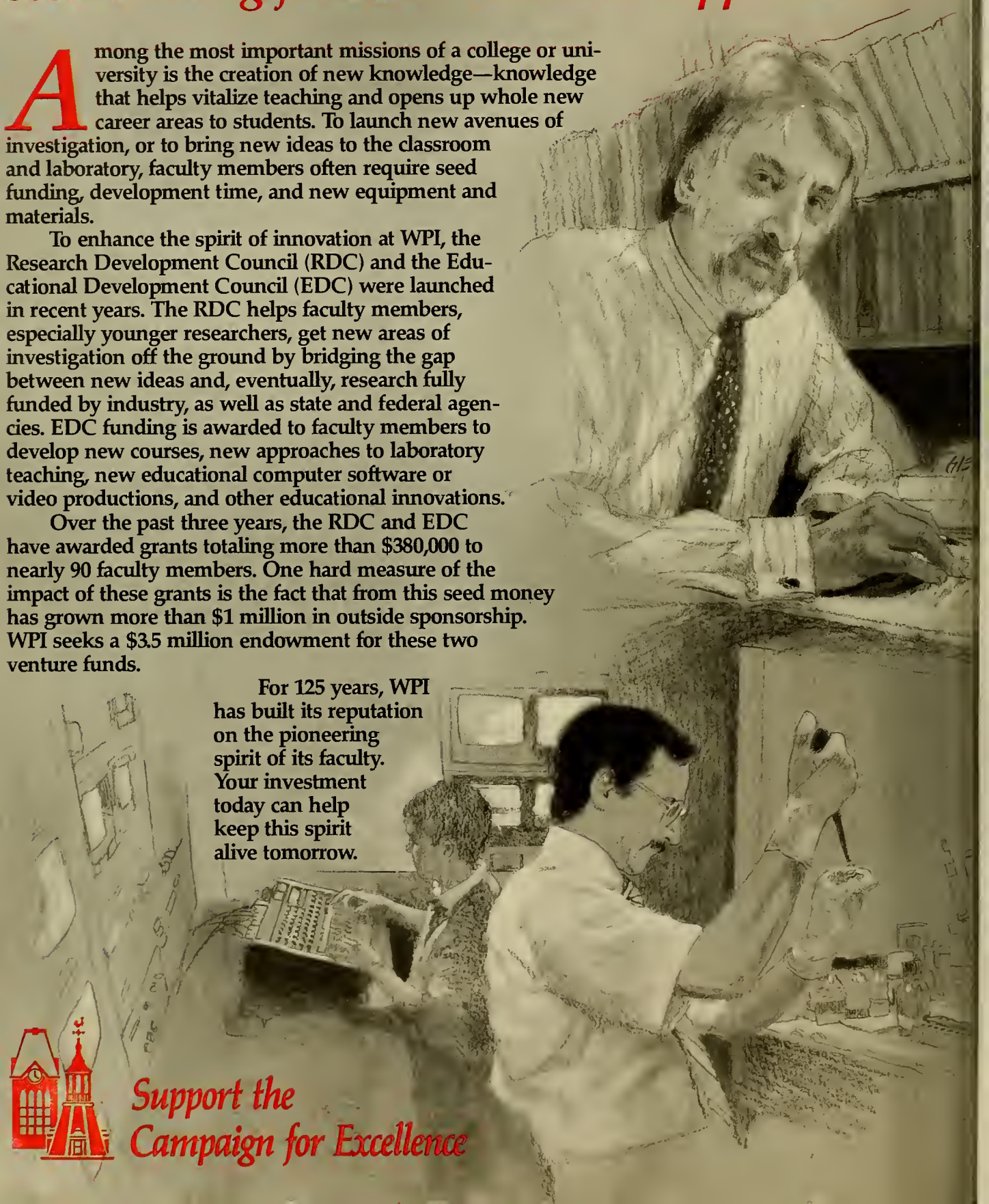
EXCELLENCE IS...

Seed Funding for New Academic Opportunities

Among the most important missions of a college or university is the creation of new knowledge—knowledge that helps vitalize teaching and opens up whole new career areas to students. To launch new avenues of investigation, or to bring new ideas to the classroom and laboratory, faculty members often require seed funding, development time, and new equipment and materials.

To enhance the spirit of innovation at WPI, the Research Development Council (RDC) and the Educational Development Council (EDC) were launched in recent years. The RDC helps faculty members, especially younger researchers, get new areas of investigation off the ground by bridging the gap between new ideas and, eventually, research fully funded by industry, as well as state and federal agencies. EDC funding is awarded to faculty members to develop new courses, new approaches to laboratory teaching, new educational computer software or video productions, and other educational innovations.

Over the past three years, the RDC and EDC have awarded grants totaling more than $380,000 to nearly 90 faculty members. One hard measure of the impact of these grants is the fact that from this seed money has grown more than $1 million in outside sponsorship. WPI seeks a $3.5 million endowment for these two venture funds.



For 125 years, WPI has built its reputation on the pioneering spirit of its faculty. Your investment today can help keep this spirit alive tomorrow.

Support the Campaign for Excellence